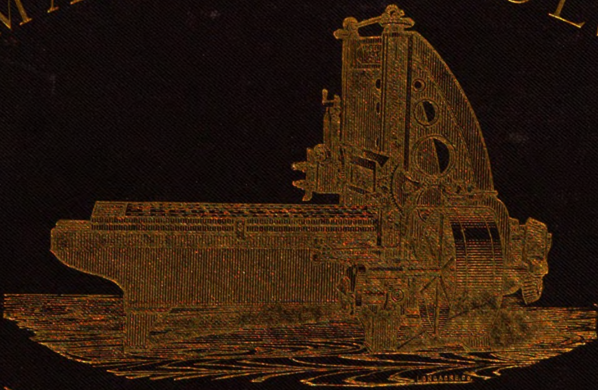
MACHINE TOOLS.



WM. SELLERS & CO.

DIPLOMA OF HONOR AWARDED TO WM. SELLERS & CO. AT VIENNA, 1873.

See page 50.

A TREATISE

ON

MACHINE-TOOLS, ETC.

AS MADE BY

WM. SELLERS & CO.,

1600 Hamilton Street, Philadelphia, U.S.,

MANUFACTURERS OF

MACHINISTS', FOUNDERS', SMITHS', AND BOILER-MAKERS' TOOLS,

SHAFTING AND MILL GEARING,

RAILWAY TURNING AND TRANSFER TABLES,

PIVOT BRIDGES, ETC.,

MANUFACTURERS OF THE

MOST IMPROVED FORMS OF INJECTOR BOILER-FEEDERS;

AND

SOLE MANUFACTURERS OF THE SELF-ADJUSTING INJECTOR.

THIRD EDITION, REVISED.

PHILADELPHIA:
PRINTED BY J. B. LIPPINCOTT & CO.
1876.

MACHINE TOOLS.

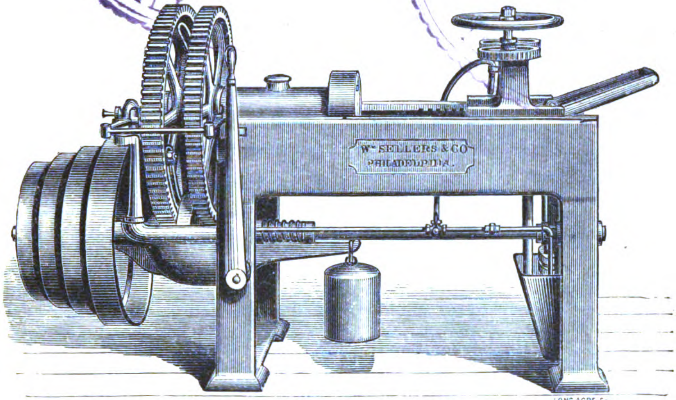
PREFACE.

IN preparing the edition of our Treatise for 1876, we have had in view the same object that prompted the issue of the first edition in 1874, namely, to present to users of machine tools such a description of the various machines made by us as is usually given verbally to those who visit our works to purchase. We do not pretend to make it a treatise on machine tools in general, but we aim to describe such tools as we make, to show their adaptation to their intended uses, and to give some hints as to how to work them to the best advantage.

The rapid advancement of engineering rendered possible by the invention of machines to do the work required, demands constant addition to the list of such machines. New wants are every day arising, requiring fresh exertion of designing skill in the production of tools to meet these wants, so that any book descriptive of this kind of machinery can only embody what was in operation at the time it went to the press.

WM. SELLERS & CO.

Fig. 1.



PATENT BOLT AND NUT SCREWING MACHINE.

With improved die-box, fitted with adjustable dies, to compensate for wear; automatic self-opening attachment, adjustable in length of bolt threaded; self-acting oil-feeder, for dies and taps; full set of taps, with tap-holders, for the range specified; over head shaft, pulleys and ball-and-socket hangers complete; wrought-iron work case hardened.

The advantages claimed for these machines over others in use are:

1st. The dies revolve and the bolt is stationary, which enables the workman to put in a fresh bolt without stopping the machine, and on long bolts is much more convenient than to revolve the bolt.

2d. The motion of the dies is always in one direction, and the bolt is cut at one operation; the dies open while they are revolving, consequently they leave no mark on the thread.

3d. The dies never run backward; the cutting edge will last much longer than when the motion of the die is reversed.

4th. The dies are adjustable, so as to compensate for wear.

5th. The dies can be changed without taking off any of the die-holding apparatus, and in less time than they can be changed in a common hand-screwing stock.

6th. The bolt-holder is arranged so as always to chuck the bolts

in the centre of the dies, thus insuring correct work when the bolts come to be put in their places.

7th. The self-acting oil-feeder insures thorough lubrication of the dies, effectually prevents their heating, and is so arranged as to wash the chips out of the die-box.

8th. The automatic self-opening attachment insures uniformity in length of bolt threaded.

Size of Machine.	Range of Cut.	No. of Taps sent with each.	Speed of Counter.	Size of Fast and Loose Pulleys.			
				Diam.	Face.		
					Loose.	Fast.	Loose.
$\frac{3}{4}''$	$\frac{1}{4}''$ to $\frac{3}{4}''$	8	200 rev's per min. in all cases.	12″	7″	4″	7″
1″	$\frac{5}{16}''$ to 1″	8		13″	7″	4″	7″
$1\frac{1}{2}''$	$\frac{1}{2}''$ to $1\frac{1}{2}''$	8		14″	8″	$4\frac{1}{4}''$	8″
2″	$\frac{3}{4}''$ to 2″	8		19″	8″	$4\frac{1}{4}''$	8″
$2\frac{1}{2}''$	1″ to $2\frac{1}{2}''$	8		20″	8″	$4\frac{1}{4}''$	8″
3″	$1\frac{1}{8}''$ to 3″	9		22″	8″	5″	8″
4″	$1\frac{1}{2}''$ to 4″	9		26″	8″	5″	8″

IN these machines the bolts are cut as with solid dies, at one operation,—*i.e.*, with once going over, but the dies open under cut when the work is done, and in releasing the bolt remove all trace of the chip made by the cutting tools. The specification on page 7 clearly expresses the advantages of the machine.

Index on back of driving wheel.

On the back of the large driving wheel is an index or pointer, which must be set to numbers given on a card sent with each machine. When so set, the bolt will fit a nut of corresponding size cut with the tap sent with machine.

Adjustment of size of bolt.

An adjustment of the index, one way or the other, will cause the bolt cut to be larger or smaller, thus permitting the thread to be adapted to the use required of it, and also permitting an adjustment of dies to compensate for wear.

Some important improvements have recently been made in this machine, viz.: a slight change in the mode of driving has enabled us to run them at a higher speed, and a novel oil-feeding device supplies the oil to the back of the dies, whence flowing out, it thoroughly lubricates the cutters and the bolt end, and washes out the chips as they are cut from the bolt. A regulating cock in the feed-pipe directs the oil either to the dies as above stated, or to the tap when the machine is used as a nut tapper. **Oil-Feeder.**

Added to this a convenient adjustable stop-motion is provided whereby the dies are opened automatically when a given length of thread has been cut. **Adjustable Stop-motion.**

These improvements have added greatly to the value of this important tool, which is made and used extensively in England and on the Continent, and is believed to have no equal in durability and efficiency. **Use abroad.**

These machines are fitted with dies for cutting V threads only, and, when not otherwise specified, we furnish taps and dies corresponding with the American standard, which was recommended for general adoption by the *Franklin Institute of the State of Pennsylvania for the Promotion of the Mechanic Arts, at a meeting held December* 15, 1864. **V threads. American standard.**

We can adapt dies for cutting coarse-threaded wood or "lag" screws, and so also dies for cutting square threads; in case of the latter, it is advisable to make the cut with more than once going over, to produce smooth work. Unless specially ordered to the contrary, our machines are always adjusted to cutting threads to standard diameters, and iron used in bolts should be swaged down on part where screw is to be cut to the proper size. **Wood screws and square threads. Cuts to standard diameter.**

Counter-shaft. The counter-shafts of our bolt cutters are made with two loose pulleys, one on each side of a fast one, so that open and cross belts can be used to run the machine backwards as well as forwards. This running backwards is only of use in recutting dies, or cutting left-handed screws. To sharpen the dies, they must be softened, and then recut with hobs, which we make for this purpose, but which are not included in the price of the machine, inasmuch as when more than one machine is in the same shop one set of hobs and collars will do for them all. The hobs are guided in recutting dies by collars fitting in a hollow sleeve, which guide a prolongation of one end of the hob, while the other end is steadied in the clamp for holding the bolts to be cut. This insures perfect concentricity to the dies. It must be borne in mind that in the use of bolt cutters, oil should be freely used upon the work. This on the new style machine is accomplished by the automatic feed; and the oil used should be *animal*, not from *coal*. The commonest lard or fish oil will answer a good purpose.

Recutting dies.

Hobs for recutting.

Collars sent with hobs.

Use animal oil only.

With each machine we send full printed directions for setting the dies and for repairing them. All parts of our bolt machines are made to gauge, and dies fitted to one machine can be used in any other machine of the same size of our make. We can therefore make new dies of any required thread to be used in any one of these machines, without having the machine in which they are to be used to fit them to.

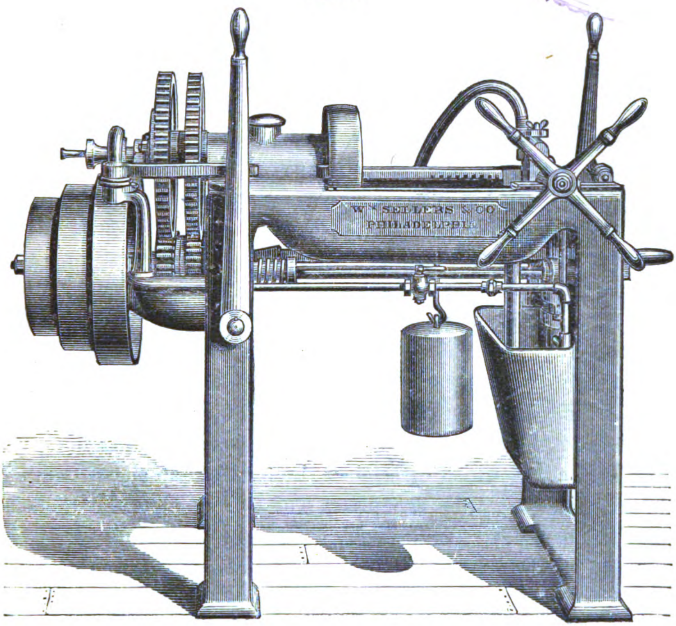
Can furnish new dies.

This is of great importance in the case of special dies being needed for any purpose, when the user of the machine has no convenience for producing new dies. The sharpening or recutting of the dies is readily done by any mechanic, but either blank dies or finished

dies can be readily furnished to those who do not desire to make them.

Fig. 2 represents our $\frac{3}{4}''$ size of machine, intended to cut from $\frac{1}{4}''$ to $\frac{3}{4}''$. This size is admirably adapted to cut set-screws and small

Fig. 2.



bolts. One man has, in a day of ten hours, cut three thousand $\frac{3}{4}''$ set-screws on a machine of this size. They were threaded close up to the head, and were two inches long on the part threaded. This excessive work done by one set of dies did not cause them to heat. We find that the new self-oiling device economizes oil, inasmuch as the bolt is lubricated only on the part being threaded, and not over any needless part of the body of the bolt.

THE AMERICAN STANDARD SCREW THREAD.

THIS form of screw thread for ordinary bolt and nut use, to which allusion has been made on page 9, grew out of an investigation of this subject made by Mr. William Sellers, and presented to the Franklin Institute of the State of Pennsylvania in a paper read by him April 21, 1864. In this, after commenting on the importance of a uniform system of screw threads and nuts, he urges the desirability of some system that would permit its expression in formulæ, and that could be reproduced at any time as original with ordinary tools and instruments of measurement. He objected to the form of thread known as the Whitworth standard, and says:

"The form of thread adopted by the English engineers is one with flat sides, at an angle to each other of 55°, with a rounded top and bottom. The proportions for the rounded top and bottom are obtained by dividing the depth of a sharp thread having sides at an angle of 55° into six equal parts, and within the lines formed by the sides of the thread and the top and bottom dividing lines, inscribing a circle, which determines the form of top and bottom of thread. Judging from the practice of this country, the English form of thread has not met with the same favor that has been accorded to their pitches. Its advantages over the sharp thread are: increased strength to the screw from the absence of acute corners, and the greater security from accidental injury which the rounded top possesses. Its objectionable features are, first, that the angle of 55° is a difficult one to verify; it is probable no gauges to this angle, made independently of each other and without special tools, would correspond with sufficient accuracy. Secondly, the curve at the top and bottom of the thread of the screw will not fit the corresponding curve in the nut, and the wearing surface on the thread will be thus reduced to the straight sides merely. It is not to be inferred from this that these curves cannot be made

to fit, but only that the difficulties in producing contact are so much increased by the peculiar form, that in practice it will not be accomplished. Thirdly, the increased cost and complication of cutting tools required to form this kind of thread in a lathe, it being requisite that this tool shall have at least three cutting-sides, in order to form the round top between two of them. The English practice for small work is to rough out in a slide-lathe with a single-point tool having sides of the proper angle, and finish in a hand-lathe with a comb-chaser, which has been dressed to the proper form upon a hob kept for that purpose, requiring three kinds of cutters and two lathes to perform what with our practice requires but one cutter and one lathe. On large work the screw is finished in the slide lathe, with a chasing tool dressed to the proper form upon a hob; and as these hobs are necessarily the standards of form until worn out, it is fair to suppose the shape must be undergoing a continual change."

He then continues:

"The necessity of guarding the edge of the thread from accidental injury becomes more and more apparent as the size of the bolt is increased, and we have recognized this by finishing such bolts with a small flat upon the top of the thread; but no plan has been proposed for general adoption upon all screws, nor have any proportions been suggested where a flat is desired, or where from the size of the bolt it would seem to be necessary. As it is very desirable that some uniform rule should be observed in the formation of all threads, and as the sharp top is objectionable upon large screws, this form must be abandoned if we would accomplish our object. It being conceded that the flat angular sides are necessary, we have only to choose between the rounded and flat top; and, having examined the former, it only remains to notice whether the flat will be found free from the objections urged against the round. As the sides of the thread are the only parts requiring to be fitted, and as these are of the same shape as the sharp thread, the one will be as easily made as the other. The width of the flat top will

2

be determined by the depth to which the thread is cut, so that the same tool can be used in both cases. The flat on the top of the thread being required to protect it from injury, it is evident a similar shape at the bottom would give increased strength to the bolt as well as improve its appearance. To give this form requires only that the point of the cutting tool shall be taken off, and then it is evident this thread can be cut in a lathe with the same tool and in the same manner as the sharp thread. The width of flat in the bottom of thread being dependent upon the amount taken off the point of the tool, it becomes necessary not only to determine what this amount shall be, but also to provide a means of measuring it.

* * * * * * * *

"The angle of the proposed thread is fixed at 60°, the same as the sharp thread, it being more readily obtained than 55°, and more in accordance with the general practice in this country. Divide the pitch, or, which is the same thing, the side of the thread, into eight equal parts, take off one part from the top and fill in one part in the bottom of the thread, then the flat top and bottom will equal one-eighth of the pitch, the wearing surface will be three-quarters of the pitch, and the diameter of screw at bottom of the thread will be expressed by the formula $\text{diam.} - \dfrac{1.299}{\text{per in.}}$. These proportions will give the depth of the thread almost precisely the same as the English, and as the wearing surface on all screws will be confined practically to the flat sides, we shall find that upon the proposed plan this will be 36 per cent. greater than on the English."

* * * * * * * *

A system of uniform dimensions for bolt heads and nuts being intimately connected with the subject discussed, he believed that a convenient formula that would express the required size would go far towards inducing a uniform practice, and with this view he submitted formulæ and tables for screw threads and nuts which he

offered for the acceptance of our engineers; thinking that should they meet the approval and be adopted by any considerable portion of the profession, there was every reason to believe they would soon be applied universally.

At the meeting at which this paper was read it was resolved that a special committee be appointed to investigate the question of the proper system of screw threads, bolt heads, and nuts, to be recommended by the Institute for general adoption by American engineers.

The committee handed in their final report at the meeting of the Institute held December 15, 1864, in which they discuss the form proposed by Mr. William Sellers, also the other features of his system, and offered a resolution which embodied his views, as follows:

"*Resolved*, That the Franklin Institute of the State of Pennsylvania recommend, for general adoption by American engineers, the following forms and proportions for screw threads, bolt heads, and nuts, viz.:

"That screw threads shall be formed with straight sides at an angle to each other of 60°, having a flat surface at the top and bottom equal to one-eighth of the pitch. The pitches shall be as follows, viz.:

Diameter of bolt...	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{1}{2}$	$1\frac{5}{8}$	$1\frac{3}{4}$	$1\frac{7}{8}$
No. threads per in.	20	18	16	14	13	12	11	10	9	8	7	7	6	6	$5\frac{1}{2}$	5	5
Diameter of bolt...	2	$2\frac{1}{4}$	$2\frac{1}{2}$	$2\frac{3}{4}$	3	$3\frac{1}{4}$	$3\frac{1}{2}$	$3\frac{3}{4}$	4	$4\frac{1}{4}$	$4\frac{1}{2}$	$4\frac{3}{4}$	5	$5\frac{1}{4}$	$5\frac{1}{2}$	$5\frac{3}{4}$	6
No. threads per in.	$4\frac{1}{2}$	$4\frac{1}{2}$	4	4	$3\frac{1}{2}$	$3\frac{1}{2}$	$3\frac{1}{4}$	3	3	$2\frac{7}{8}$	$2\frac{3}{4}$	$2\frac{5}{8}$	$2\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{3}{8}$	$2\frac{3}{8}$	$2\frac{1}{4}$

"The distance between the parallel sides of a bolt head and nut, for a rough bolt, shall be equal to one and a half diameters of the bolt plus one-eighth of an inch. The thickness of the heads for a rough bolt shall be equal to one-half the distance between its parallel sides. The thickness of the nut shall be equal to the

diameter of the bolt. The thickness of the head for a finished bolt shall be equal to the thickness of the nut. The distance between the parallel sides of a bolt head and nut, and the thickness of the nut, shall be one-sixteenth of an inch less for finished work than for rough.

"*Resolved*, That a copy of these resolutions be forwarded to the Quartermaster-General, Chief of the Bureau of Steam Engineering of the Navy, and the Chiefs of Ordnance for the Army and Navy, and Chiefs of the Engineer and Military R. R. Corps, and the Supt. and M. M. of R. R. Companies, requesting them to use their influence to promote the adoption of a uniform system of screw threads, bolt heads, and nuts by requiring all builders under any new contracts to conform to the proportions recommended.

"*Resolved*, That a copy of these resolutions be also sent to all Mechanical and Engineering Associations or Institutes, and the principal machine and engine shops in the country, with a request that they will use their influence in the proposed system.

"*Resolved*, That this Committee be now discharged.

"Wm. B. Bement, *Firm of Bement & Dougherty.*
"C. T. Parry, *Supt. Baldwin's Locomotive Works.*
"J. Vaughan Merrick, *Firm of Merrick & Sons.*
"John H. Towne, *Firm of I. P. Morris, Towne & Co.*
"Coleman Sellers, *Eng. Wm. Sellers & Co.*
"B. H. Bartol, *Supt. Southwark Foundry.*
"E. Longstreth, *Foreman Baldwin's Locomotive Works.*
"James Moore, *Firm of Matthews & Moore.*
"Wm. Sellers, *Firm of Wm. Sellers & Co.*
"Algernon Roberts, *of the Pencoyd Iron Works.*"

After the acceptance of this report and the adoption of its resolutions, many of the leading railroads and machine makers accepted this standard, known as the Franklin Institute standard.

On May 15, 1868, Mr. B. F. Isherwood, Chief of Bureau of Steam Engineering, submitted to the Hon. Gideon Welles, Secre-

tary of the Navy, the report of a Board to recommend a standard gauge for bolts, nuts, and screw threads for the United States Navy. This report, which has been published for use of the navy yards and naval steamers, reviews the subject in a thorough and practical manner. It considers the general practice of the leading workshops of the country, and unhesitatingly indorses what it calls the system of Mr. Sellers. Its recapitulation expresses the formulæ thus:

Let

D = nominal diameter of bolt.
p = pitch of thread.
n = number of threads per inch.
H = depth of nut.
d_n = short diameter of hexagonal or square nut.
d = effective diameter of bolt = diameter under root of thread.
s = depth of thread.
h = depth of head.
d_h = short diameter of head.

Then—

$$p = 0{\cdot}24 \sqrt{D + 0.625} - 0.175.$$

$$n \text{ [number of threads per inch]} = \frac{1}{p}.$$

$$s = 0.65\,p.$$

$$d = D - 2\,s = D - 1.3\,p.$$

$$H = D.$$

$$d_n = \tfrac{3}{2}\,D + \tfrac{1}{8}''.$$

$$d_h = \tfrac{3}{2}\,D + \tfrac{1}{8}''.$$

$$h = \tfrac{3}{4}\,D + \tfrac{1}{16}.$$

It then gives a table of screw threads the same as that recom-

2*

mended by the Franklin Institute, with the one difference and that regarding the size of finished or unfinished bolt heads and nuts. The navy report makes no difference in the size of either —that is, for finished work the forgings must be made larger than for rough; their idea being to use the same wrench on either black or finished work. In reference to their tables they say:— "The only instance where the values in the table differ from those given by the formulæ is in the number of threads per inch, which is so far modified as to use the nearest convenient aliquot part of a unit, so as to avoid, as far as practicable, troublesome combinations in the gear of screw-cutting machines." Then—

"In concluding this report the Board desires to say, that in recommending the system of Mr. Sellers as a standard for the navy, it has been governed by considerations other than those suggested by the merits inherent in the system itself.

"Fully realizing the importance of entire uniformity of practice in private establishments as well as in the navy, we were naturally desirous to select a system which, while meeting all the essential requirements of a system, would be most likely to be generally acquiesced in and adopted.

"So far as we have been able to confer with engineers and manufacturers, either personally or by letter, we have heard but one opinion expressed in regard to the importance of uniformity of practice. Many have already adopted the Sellers pitch; others are gradually adopting it; while others still express their willingness to adopt it. A majority, we confidently believe, are now willing to adopt Sellers' form of thread also, provided it be made the standard."

This report was signed by

THEO. ZELLER, *Chief Engineer U. S. Navy.*

ALEXANDER HENDERSON, *Chief Engineer U. S. Navy.*

D. M. GREENE, *First Ass't Engineer U. S. Navy.*

Chief Engineer B. F. ISHERWOOD, U.S.N., *Chief of Bureau of Steam Engineering.*

In answer to the letter of Mr. Isherwood, accompanying the report, the Secretary of the Navy writes:

"NAVY DEPARTMENT, May 16, 1868.

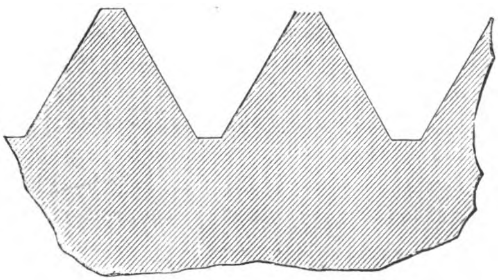
"SIR,—The standard for the dimensions of bolts and nuts, as determined by the Board, is, upon your recommendation, authorized for the naval service.

"(Signed) GIDEON WELLES,

"*Secretary of the Navy.*

"Chief Engineer B. F. ISHERWOOD, U.S.N., *Chief of the Bureau of Steam Engineering.*"

The system was also introduced in other departments; and of the many hundred bolt cutters made by us since the introduction of the system, very few have been fitted with any other screw thread; and it has met with such general favor that it can safely be considered as the American Standard.



SURFACE GRINDING MACHINE.

Arranged to grind flat surfaces of hardened steel. The top plate, or table, of cast iron, with hard steel plate at centre, made truly plane. Emery wheel on hardened steel mandrel, running in composition bearings. Frame that carries the frame-table arranged to set on ordinary work bench. Counter-shaft to be placed on floor below it, has fast and loose pulley 5 inches diameter, $2\frac{1}{2}$ inches face, which should make 320 revolutions.

THE introduction of true surface plates for use in machine shops has rendered the production of plane surfaces in cast iron, or other metals

Scraped surfaces.

that can be worked by scraping, a comparatively easy matter. But a want has been long felt for some means of producing a true plane on hard substances, as, for instance, on hardened steel. Our surface grinding machine is, in fact, an abrading or grinding device in the centre of a true plane; the abrading mechanism being adjustable to any degree of depth of cut. Hard surfaces passed back and forth over this abrading mechanism, come in time to be a copy of the plane surface upon which they rest. The cutting is done

Emery wheel.

by an emery wheel on a horizontal axis, the edge of the wheel extending just through the plate. The surface plate, which is 18 inches long by 8 inches wide, rests on two supports at one end, and on an adjusting screw at the other. This little machine, like the drill grinding machine, page 40, finds its proper place in the tool-room, and serves an admirable purpose in the production of hardened straight edges, and in dressing up flat surfaces of dies and cutters.

DRILL PRESSES.

UNDER this head we class all machines used for boring, in which the cutters revolve and the work remains stationary; while under the head of BORING MACHINES we place those machines used for boring only, or boring and turning, in which the cutters are stationary and the work operated on revolves.

Some of the machines classed under the head of drill presses are known as boring machines, the word "bore" being commonly applied to holes of a size requiring the use of independent cutters inserted in a "boring bar." We are satisfied that a power feed is essential to all machines for cutting metal. The drill press is no exception to this; yet it is almost the only machine tool which has commonly been built with a hand feed only. The conditions of cut and variations in the size and strength of the cutting tool make the application of an automatic feed to a drill press a more difficult matter than to a lathe or a planing machine, in which a given-sized cutting tool of sufficient strength to do the work is possible. In a drill press the smaller and more delicate the drill the finer and more exact or uniform must be the feed. The requirements of a good feed motion for a drill press are: that it may be quickly adjusted to the required amount; that it shall be, to all intents and purposes, positive in its action when at work, yet be capable of yielding without endangering the drill if too heavy a strain comes on the cutting edges; that it shall be so quickly and readily applied as to make its use more convenient than the hand feed; and that it shall not in any way interfere with the quick operation of the machine by hand.

The introduction of our patent adjustable feed motion fully satisfies all the requirements of a feed for drilling machines. In this we employ discs of metal to transmit motion by friction, and which,

being adjustable as to diameter of driving and driven wheels, admits of an infinite variation of feeds between its extreme limits of greatest and least motion. This peculiar feed motion is applied to those of our drill presses in which range is desirable; but in machines for special work, such as our press for drilling steel rails, the feed is constant, at what has been found to work the best, as the size of the drill used in such machines is in a measure constant also. In vertical drill presses we always counterbalance the spindle. This is of great value, as the drill held up by the balance-weight will not drop into holes or cavities in the metal, and is much less liable to break. It will be seen in the following pages that we have patterns of drill presses with hand feed only, but we do most emphatically recommend the power feed, where first cost is not the essential consideration of the purchaser.

We would also call attention to a recent improvement in horizontal drills, whereby we can readily and quickly shift from a fine feed for the roughing cut to an exceedingly coarse feed for the finishing cut. This enables the finishing or sizing cutters to be hurried through their work, with a great saving in time, with less wear of the cutters, and consequently with more accurate results, especially in deep holes.

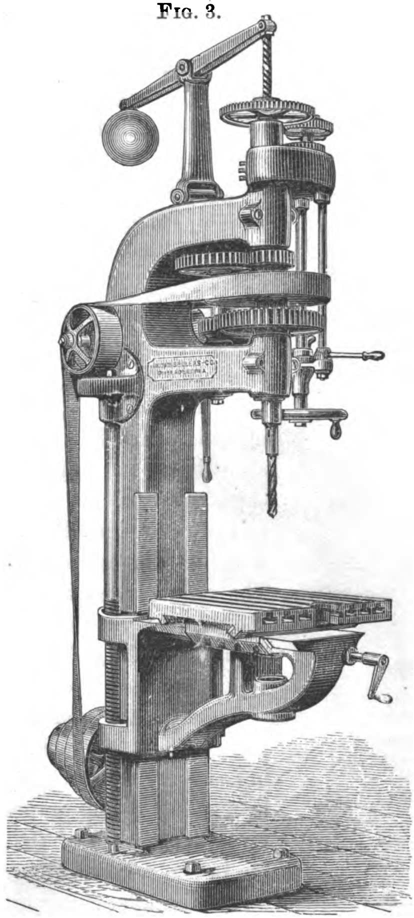
There are also many improvements in this class of machines, which will be alluded to under the heads of the respective tools. In this introduction we merely wish to call attention to the features common to almost all our drill presses.

In regard to the proper shape of the cutting edges of the drills themselves, we present under the head of Drill Grinder, p. 40, our views on this subject, and explain how they may be cheaply maintained in good order at small expense.

The various requirements of trade necessitate many devices in drilling and boring machines. We have arranged many such special tools not illustrated in this book. Some of the machines here shown and intended for general work can be modified to meet the requirements of manufacturers.

PATENT DOUBLE-GEARED VERTICAL DRILL.

FIG. 3.



With square column, plain or compound tables, raised and lowered by screw operated by power. The table arranged to swing to one side. The knee carrying table is provided with a bearing to hold lower end of boring bar. Drill spindle counterbalanced with quick hand and variable power feed, always in gear, but not interfering with the rapid movement of spindle vertically by hand. Spindle best cast steel; driving pulley on the spindle, so that when back gear is not in use the spindle is driven by belt only, *producing a particularly smooth motion for small drilling.* Cone pulley is at base of column, admitting ready change of speed; overhead shaft furnished with fast and loose pulleys, turned inside so as to be accurately balanced; a full set of wrought iron wrenches. Wrought iron work case hardened.

45-inch vertical drill, 22½ inches from centre of spindle to face of column, with either plain or compound table.

THIS machine for holes of 1½ inches and under in cast iron has its spindle driven by belt only, but is provided with back gear to be used for heavier

Driven by belt only.

Driving by belts.

work. This belting system has been found to work much better than the geared plan of driving in common use; and in practice we find that in comparison with machines of otherwise similar capacity and power of cut, the same workman can do 15 per cent. more work on this machine than on the old styles. In an experiment with small drills, the power feed was used in boring a $\frac{1}{4}$-inch hole through 3 inches thickness of wrought iron successfully, and in less time than the same hole was made by a skillful workman feeding by hand.

Post.

The supporting post of this machine is square, and the bracket carrying the compound table is gibbed on to a plain surface. The raising and lowering of the

Table.

table are effected by a screw placed at one side of post in such a position as to enable the table to swing about it as on a hinge, after slacking the shoe on the opposite side of the bracket. This enables the table to be removed readily for the introduction of such work as can more conveniently rest on the floor.

Raise table by power.

The raising screw is driven by power, so as to give the utmost facility of adjustment. We make this tool with plain table, when required; but in the majority of instances in which purchasers have selected the plain tables they have afterwards ordered the compound tables to replace them, the latter presenting so many advantages. In order that the tool may be used for boring purposes with double-ended cutter up to the capacity of the power, with the back gearing in use, we arrange in the bracket a hole to carry

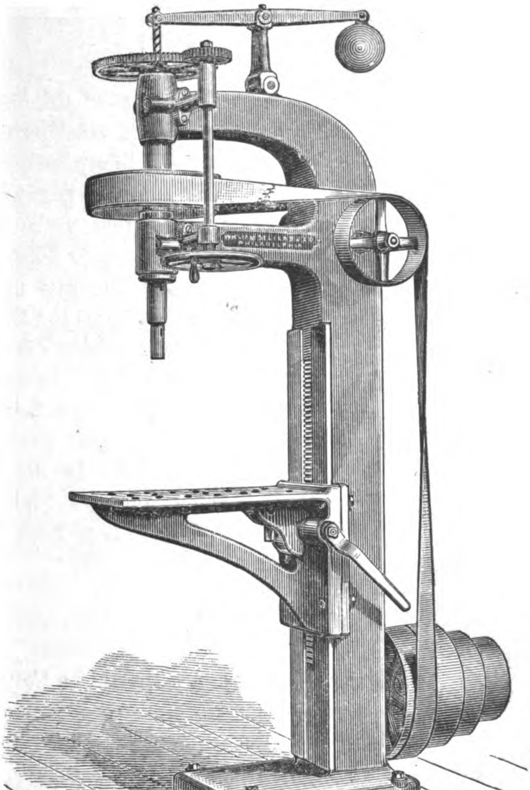
Guide for bar in bracket.

a guide bushing to support the lower end of the boring bar and to give steadiness to it under cut. On countershaft there are 10 inches by 4 inches fast and loose

Speed.

pulleys, making 110 revolutions per minute.

FIG. 4.



36-INCH VERTICAL DRILL.

Spindle of best cast steel, driven by belt only, and counterbalanced. Feed by hand on'y; has an overreach of 18 inches. Plain table, adjustable by rack to any required height. Fast and loose pulley on counter-shaft 12 inches diameter, 4-inch face; should make 110 revolutions per minute. Wrought iron work case hardened.

36-INCH VERTICAL DRILL.

THE acknowledged advantages of driving drills by belt, in preference to the usual bevel gearing, have led us to adapt this principle to all our vertical drills. The one shown on page 25 is designed to fill the want for a plain, inexpensive tool for miscellaneous drilling, and is adapted to holes in cast iron up to 1½ inches diameter. The cone pulley is at base of the square post which forms the frame of the machine, and from it a belt passing over carrying pulleys actuates the drill spindle. Owing to the smoothness of the motion imparted by a belt, more and better work is accomplished, more particularly when small holes are being drilled. In the use of machines driven by belt when running at high speed, the absence of all rattle and noise is of itself a high recommendation.

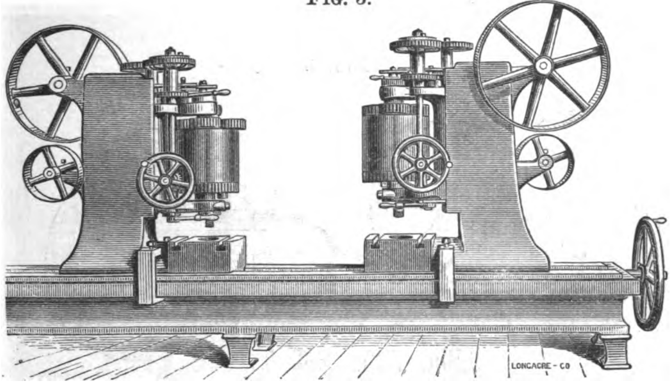
Cone pulley.

COTTER DRILL.

WE have designs and patterns of a Cotter drill having the main features of our vertical drill; which can be used as a vertical drill of the most approved form. Its peculiarities as a Cotter drill are in the adjustment and feed. The drill-traverse sideways is accomplished by a screw with an adjustable feed, the stop at each end of stroke being absolute in exactness of length of motion. This feature enables it to do more and better work than when the side motion is accomplished by means of a crank.

Traverse positive.

Fig. 5.



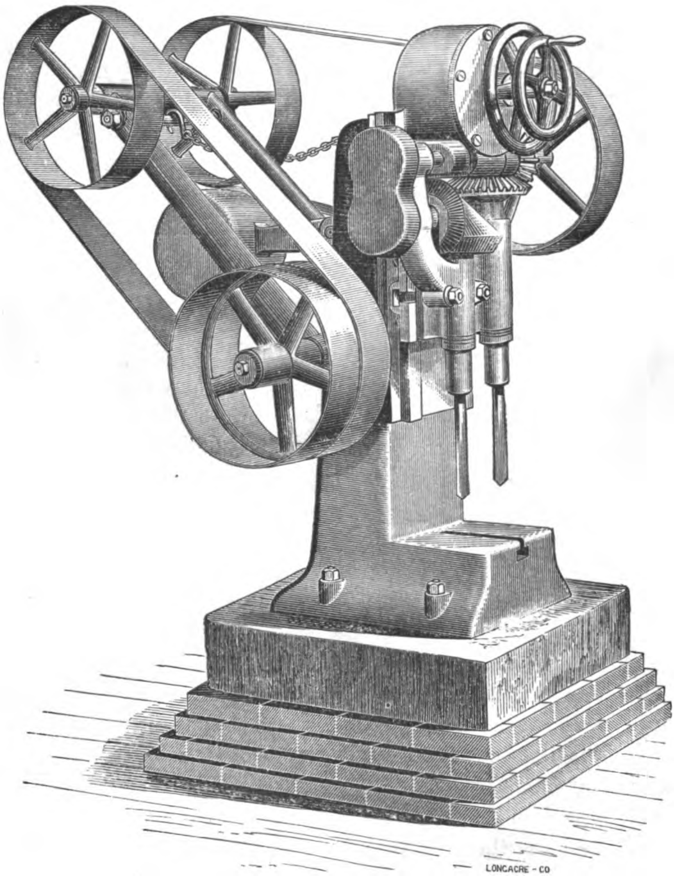
DOUBLE TRAVERSE DRILL.

IN preparing links for bridge-work, it is advisable, in order to insure accuracy in length, to bore the holes for the pins in both ends at the same time. For this purpose we make right- and left-hand boring machines, sliding on a solid bed, and adjustable to or from each other, to suit the required length of links. The boring machines are so placed as to permit the links to be put in place from one side, and, when done, passed out on the other side of the machine. The driving is effected by horizontal belts passing over guide-pulleys, and around a drum on the spindles. The cutters used in this machine are kept cool by water fed to them through the centre of the spindle.

In the link boring machine the two heads are united by bars of wrought iron and can slide freely on the cast-iron bed. The expansion of the wrought-iron bars being the same as the expansion of the link being bored, insures uniformity in the length of the finished work.

Expansion of the bed.

Fig. 6.



RAIL DRILLING MACHINE.

RAIL DRILLING MACHINE.

With square column and projecting knee to receive the rail: intended to be brought to proper height to suit trussels in mill, by resting it on foundation or pier built to a proper height. Drills adjustable in a right line, so as to be placed either 4 inches from centre to centre, or of being set 8 inches apart if required. Powerful down feed, of both drills simultaneously, and a quick return, by hand movement. Spindles of best cast steel. Arranged either with separate counter-shaft or fast and loose pulleys on machine, as may be required. Fast and loose pulleys, 18 inches diameter, 4 inches face, should make 160 revolutions per minute. Wrought iron work case hardened.

THE introduction of steel rails has necessitated the use of drilling machines to make the holes for the joint bolts near the ends of the rails. In designing this machine for the above purpose, we had in view the most efficient mode of driving the two drills, and the readiest means of adjusting them to the proper distance apart. The feed is a positive unvariable one, and is the utmost that has been found possible to use. Rapid drilling in steel is attainable rather by high speed of cut with fine feed, than by a slower speed with a coarser feed. To keep the drills in proper order for work, we recommend our drill-grinding machine as shown on pages 40 and 41.

Speed of cut.

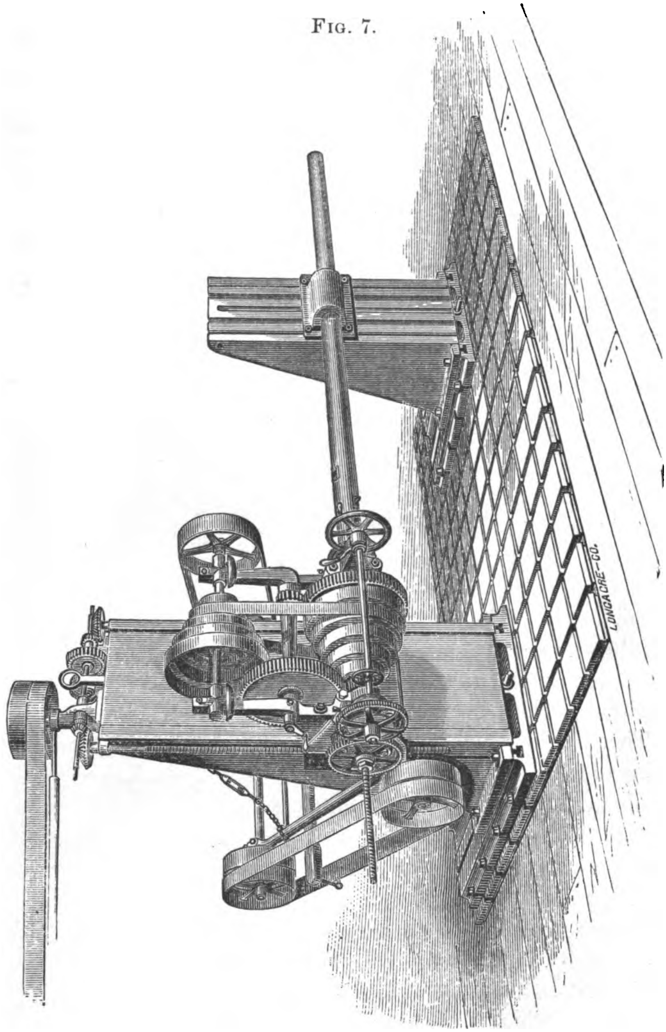
These machines are always used in pairs, one machine to each end of the rail; but not necessarily both drilling at the same time on the same rail.

Animal oil should be used in drilling steel and wrought iron; coal oil will not do. A free use of water containing soda or soap will answer a better purpose than coal oil, and will do almost as well as lard or whale oil.

Lubricant used.

We have also arranged these machines on a bed plate, upon which they traverse back and forth, enabling them to be used as a multiple drilling machine.

FIG. 7.



FLOOR BORING MACHINE.

FLOOR BORING MACHINE.

Consisting of a powerful horizontal drill press mounted on a stand, movable to position on a heavy bed-plate, the work being stationary. The bed-plate is provided with T shaped slots for the convenient clamping of work, and is 20 feet long by 5 feet wide.

THE Horizontal Drill Press having proved itself in our own practice so useful, suggested a machine which could itself be moved about the work, while the work, too heavy to be moved on the table of another machine, could be clamped on the floor, and there held until all the boring was completed.

Floor plate. To this end we have arranged a large floor-plate provided with T-shaped slots on which the machine may be clamped at any horizontal angle to the work; for such work it is much more convenient than the stationary machine, because the work once bolted to the floor need not be moved until the work on it is entirely completed.

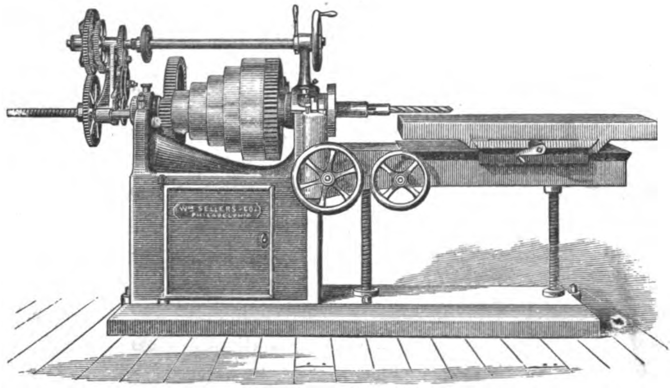
Boring drill. The boring machine itself is provided with all the devices for feed and speed found in our stationary horizontal drills.

Amount of motion. The boring bar may be moved vertically from within 14 inches of the floor, to a height of 6 feet 4 inches, thus making it capable of boring any horizontal hole.

When the bar used is a long one, steady rests are provided which may be bolted to the floor, to support the outer end of the bar.

Swing frame. Motion is conveyed to the machine by means of pulleys on a swing frame, thus allowing the machine to be moved to any position on the floor, and at the same time keep all the belts tight.

FIG. 8.



HORIZONTAL DRILLING AND BORING MACHINE.

With patent variable feed and quick hand traverse to boring spindle, arranged so as to be changed instantly from one to the other; compound tables arranged to move vertically, with horizontal movement at right angles, and parallel to drilling spindle; arbor which carries drilling spindle arranged with face plates so that the machine can be used as a facing lathe; over-head shaft; iron cone pulleys turned inside so as to be perfectly balanced; ball and socket hangers, and a full set of wrought iron wrenches. Length of traverse to drilling spindle, 24 inches. Diameter of piece will swing over table, 51 inches. Wrought iron work case hardened.

Extra slide rest to bolt on face-plate for squaring pipes or facing off work.

THIS machine, designed to bore and drill work horizontally, resting upon a table or platform, has been considered by some eminent engineers as coming next to the lathe in usefulness in the shop. It will drill work that could not be operated upon in

an ordinary drill press, and has all the advantages of a facing lathe for some kinds of work.

Speed.

The counter-shaft has 16 inches fast and loose pulley, 4 inches face, which should make 75 revolutions per minute.

Advantages.

Marked advantages which this machine has over similar tools of other makers, lie—in the nature of the feed motion, which, by use of the friction feed discs admits of an infinite variety of feeds between its finest and its coarsest; in the ready application of the feed, and its quick hand motion; also, in the manner of operating the compound table upon which the work rests,—the handles to govern the motion of table being all on one side, and within easy reach of the workman. The screws which raise the table require holes in the foundation below the bed; as when the table is lowered they project below the base of machine. If placed in damp places, the boxes or recesses in foundation for these screws should be made water-tight.

Foundation.

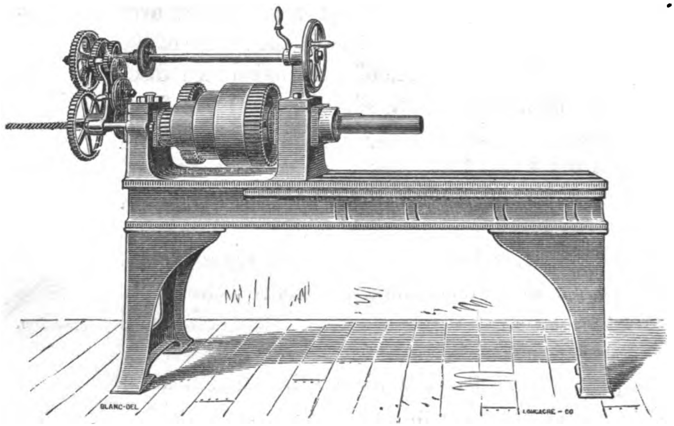
Coarse feed for finishing.

To these machines we have recently added an additional feed motion, permitting the use of very coarse feeds for finishing cuts: thus increasing the capacity of the machine in regard to amount of work done by it.

It will be observed that we represent this machine provided with a compound table, both movements being by screws. In our own practice we think this preferable to having one of the movements only operated by screws and the other a clamped table set to any required position and made fast by bolts. We have patterns for a good adjustable steady rest for the outer end of boring bar, which we recommend in place of a permanent out board bearing; but we can arrange our machines for either.

Steady rest for end of bar.

Fig. 9.



HORIZONTAL DRILLING AND BORING MACHINE FOR CAR BOXES, ETC.

With self-acting variable feed to drilling spindle; bed with flat top as in lathes; without adjustable table; especially adapted to boring car boxes and any work held in special holders; over-head shaft with ball and socket hangers and fast and loose pulleys, 14 inches diameter, 4 inches face, which should make 80 revolutions per minute.

Iron cone pulleys turned inside, so as to be perfectly balanced; full set of wrought iron wrenches. Wrought iron work case hardened.

No adjustable table.

THIS machine is in principle the same as our larger Horizontal Drill, but is not provided with adjustable tables for the work to rest on. The prolongation of the bed or shears beyond the boring head is provided with slots for bolts to enable

devices for holding special work to be readily bolted to place. It is used extensively for boring all kinds of car boxes and similar work. In any case where there is a repetition of boring on the same kind of work it has great advantages. For example: In the manufacture of the Westinghouse Air Brake, these machines are used exclusively to bore all the cylinders, not only of the pumps, but of the air cylinders, say 10 inches or 12 inches diameter, which are placed under the car. In our own case we find them of great use in the brass shop; and we use a number of them for boring hangers, hanger boxes, and couplings for our shafting. **Example of use.**

Fast and loose pulley, 14 inches diameter, 4 inches belt, 80 revolutions per minute. **Speed.**

To this machine we have adapted the new arrangement to accomplish coarse feeds for finishing cuts.

We have also a design of horizontal drill embodying the various features of this machine, so far as its head and driving gear are concerned, but provided with a table adjustable vertically, after the manner of the table on our vertical drill. See page 23.

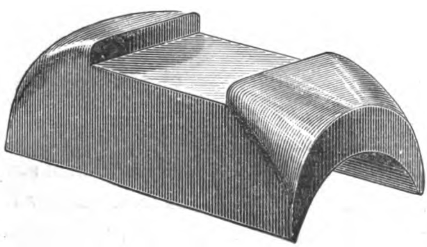
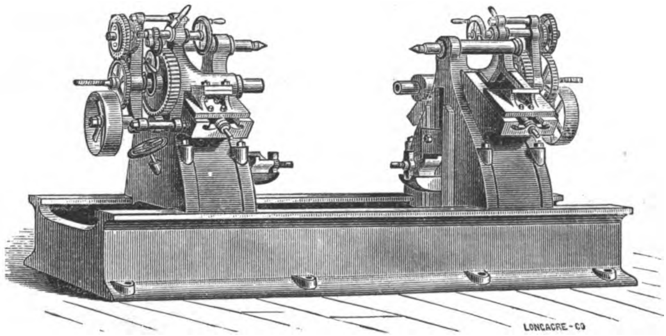


FIG. 10.



WHEEL QUARTERING MACHINE.

Quarters from 5 inches up to 13 inches radius of crank, either right- or left-hand crank lead; bores both crank holes at the same time from the outside of wheel, with self-acting adjustable feeds. Wheels and axle supported, adjusted, and secured upon tread of wheel, so as to insure great rigidity while being bored; over-head shaft with ball and socket hangers and one fast and two loose pulleys, 24 inches diameter, 8-inch face for 4 inches shifting belt, speed 86 and 120 revolutions per minute. Full set of wrought iron wrenches. Wrought iron work case hardened.

THE introduction of small short-stroke engines for mine purposes calling for some ready means of quartering wheels with a crank throw of only 5 inches, for engines of 10-inch stroke, we have so arranged this machine as to quarter from 5 inches to 13 inches radius of crank, and to bore either for right or left hand led with equal accuracy. The

boring spindles are outside of the wheels; and bore both crank holes at the same time, each spindle being driven separately and provided with adjustable automatic feed, so as to apply in practice the principle alluded to in our remarks on boring machines (page 30):—i.e., roughing out the holes with fine feed, but finishing with a wide feed and light cut. The wheels on their axle are carried by their tread on adjustable shoes, which hold them rigidly in place, while the centres control position of axis only; this insures great stability, and entirely precludes the possibility of the wheels shifting under cut or springing from pressure of cut. The bed is adapted in length for either wide or narrow gauge.

Bore from outside of wheel.

Holding wheel.

The machine is not only valuable as a quartering machine, but may be used to advantage as a horizontal drill for other purposes. For speed of countershaft, see specification on opposite page. The boring heads used are in themselves complete machines, and may be made to do good service as portable boring machines: i.e., when unbolted from the knees upon which they rest, they may be placed on any convenient stand and used for independent boring machines.

May be used as a horizontal drill.

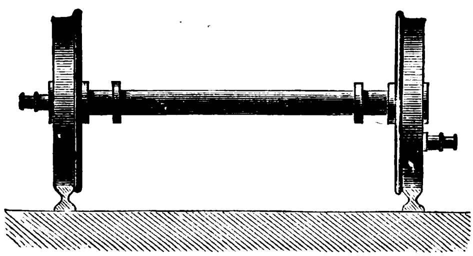
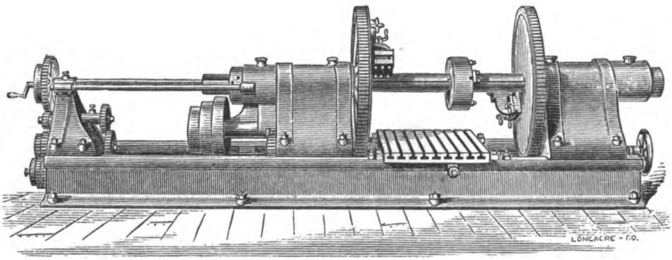


FIG. 11.



CYLINDER BORING AND FACING MACHINE.

For boring locomotive cylinders. Six-inch steel boring bar, driven at both ends of cylinder; independent slide rests for facing off both ends of cylinder; six changes of boring feed, with a quick hand feed; cutter heads to bore from 10 to 22 inches. Bar draws entirely out of cylinder by hand or power, to allow the work to be shifted. Iron cone pulleys turned inside, so as to be accurately balanced; overhead shaft, with ball and socket hangers and fast and loose pulleys, 18 inches diameter, 4 inches face, which should run 140 revolutions per minute. A full set of wrought iron wrenches. Wrought iron work case hardened.

THIS is one of the most notable of the modern special tools: it was designed to bore locomotive cylinders; and is capable of boring and facing up the flanges, also counter boring for clearance of pistons at end of stroke of a cylinder of the largest size used in freight engines or express passenger engines, in three and a half hours. This is remarkable, when the quickest time ever known to have been made in the same work previous to the construction of this machine was *nine hours:* the usual time, however, being seldom less than thirteen hours

Time taken on other machines.

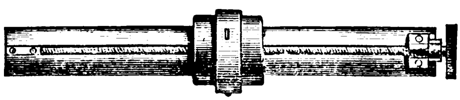
on ordinary boring machines. In performing this work the same principle is brought into play that is mentioned in our notes on Boring Mills,—one cut with a fine feed takes out the greater part of the metal. While the roughing cut is being made, the sinking head is cut off by the face plate slide rests and the flanges turned up: two finishing cuts are then run through with a feed ½ inch broad, and the cylinder counterbored at end afterwards. **Nature of feeds.**

In case of it being deemed advisable to turn the flanges up at a time when no cut is under operation, the increase of time still permits the work to be done in less than five hours to each cylinder. Fast and loose pulleys on over-head shaft, are 18 inches diameter, 4 inches belt, and should run 140 revolutions per minute. This will give speed of cut on 22 inches cylinder of 18 feet per minute. **Speed.**

BORING BAR FOR LOCOMOTIVE CYLINDERS.

WE also make a very convenient boring bar, to be used in a lathe, adapted to boring locomotive cylinders. The head on this bar traverses, and it has a device for cutting off the sinking heads of the casting.

In use, the cylinder is secured either directly to the lathe bed or to the saddle of the slide rest; but is not moved during the boring.



DRILL GRINDING MACHINE.

Arranged to grind twist and fly drills, making cutting edge of uniform angle and length, thus insuring equality of cut upon both sides. Shank of drill held in chuck, and lip of drill held in jaws, so that cutting edges will revolve perfectly true in the drill press. Fast and loose pulleys on machine, 6 inches diameter, 3 inches face, which should run 500 revolutions per minute. Wrought iron work case hardened.

AS part of our system of shop management and economy, stress should be laid on this tool. By means of it, twist or fly drills may be ground or sharpened readily, and in such a manner as to insure the cutting lips being equal and of proper angle and clearance in cut. This machine, to be efficient, should be placed in the hands of a man whose business it is to sharpen all drills used in the establishment. Any well-regulated shop should have a tool room, in which all the small tools required by workmen, such as drills, reamers, taps, mandrels, gauges, etc., are kept, and can be given out to the workmen to use, to be returned when done with or when needing sharpening. This system will make much fewer tools necessary to carry on business than will be required by the more shiftless way of allowing each workman to keep all the tools needed on his special work. The shape of the cutting edges obtained by the use of this machine is such as to give the best possible condition for cutting under all circumstances of quality of material. The fast and loose pulleys on the machine are 5 inches diameter, 2¾ inches belt, and should make 500 revolutions per minute. The grinding wheel sent with the machine is made of emery, and will, with care, last several years in constant use.

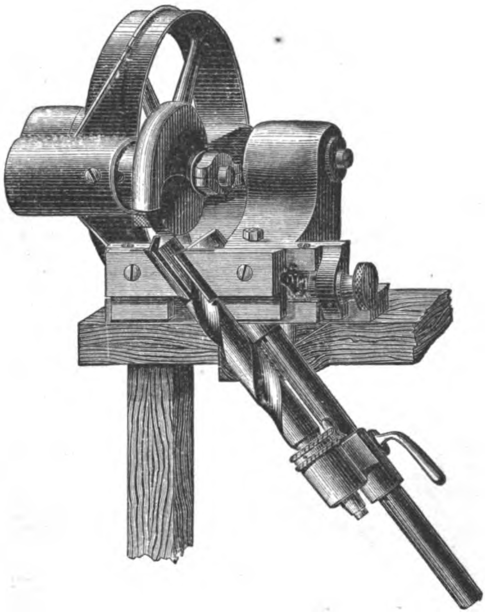
Tool room.

Shape of lips.

Emery wheel.

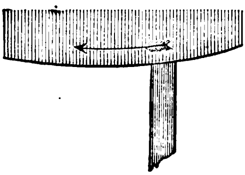
The cut, Fig. 12, illustrating our Drill Grinding Machine, shows a twist drill in position for grinding. It will be observed that the end of the drill near to the cutting edges is held in a clamp vice. The emery wheel passed back and forth over the lip, which is in a horizontal position, grinds it to a true line. Then, upon slacking the clamp vice and turning the drill half-way around by means of an index plate at the shank end of drill, the other lip is in position to be ground to correspond with the first. This principle of clamping the end of the drill for each lip insures absolute equality in the length and cutting property of each lip, provided the last pass of wheel over the two lips be made without vertical adjustment of the emery wheel. The bar which carries the socket for holding the drill shank is placed at an angle that has been found by experience to give the best average result in cast and wrought iron. The drill when clamped is so placed in regard to the emery wheel as to insure proper clearance on fly drills. Twist drills will have clearance for its cut near the edge of

FIG. 12.



drill, but must be backed off up to this surface by hand, on a grindstone. We esteem the absolute rigidity of the clamped lips added to the simplicity of the machine, as preferable in practice to any more complicated and less rigid devices for grinding a curved clearance over the whole surface of the ends of twist drills. Fig. 13 shows the position of the grinding wheel in reference to the edge of a fly drill, and indicates the method of obtaining clearance.

FIG. 13.



In setting a twist or fly drill in place in the clamping jaws, care must be taken to place its cutting edge as nearly as possible parallel with the line of motion of the wheel in passing

FIG. 14.

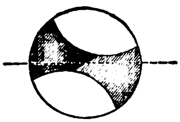
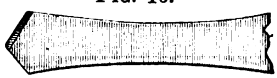


FIG. 15.

back and forth over its length, as is shown in Fig. 14 for twist drills, and Fig. 15 for fly drills.

Fly drills, made as shown in Fig. 16, cannot be ground with any

FIG. 16.



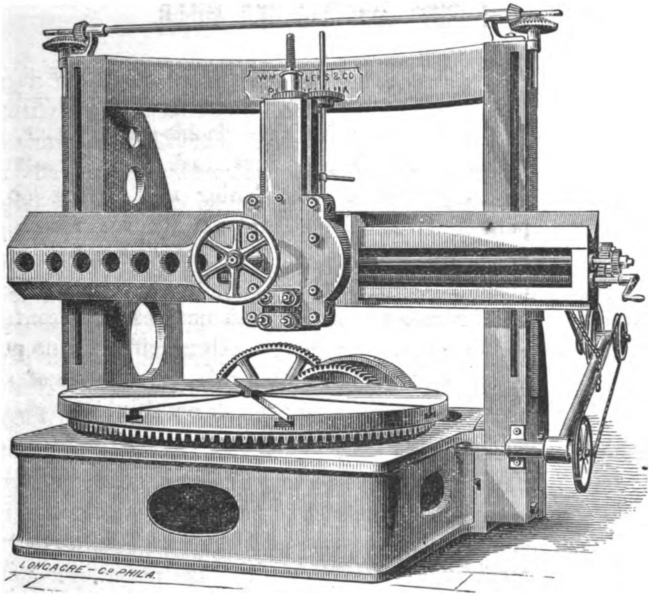
exactness; there should be a portion of the length of drill with parallel sides for some little distance above the lips, as is shown in Fig. 17.

FIG. 17.

This condition exists in twist drills.

FIG. 18.

FIG. 19.



BORING AND TURNING MILL,

WITH

COMPOUND SLIDE REST AND BORING BAR COMPLETE.

The holder for boring bar is so arranged as to be easily removed and a turning tool substituted; feeds self-acting in all directions, and at all angles; quick return motion to boring bar; face plate resting in an angular bearing after the manner of the slide of a planing machine; with an adjustable centre step to take any amount of the vertical strain that may be desired; over-head shaft; iron cone pulleys turned inside so as to be perfectly balanced; ball and socket hangers and wrought iron wrenches complete. Wrought iron work case hardened.

BORING AND TURNING MILLS.

THESE mills, the smallest of which has a capacity of 84 inches, are adapted to bore with a boring bar having a double-ended cutter, or to bore with a single-pointed tool. Can be advantageously used in both boring and turning large pulleys, and in doing all work usually done on a facing lathe, with the advantage of ease of chucking, inasmuch as the face plate being horizontal, work laid upon it may be moved about until correctly centred and then clamped to place. These mills have no part of the machinery extending below the surface of the floor upon which they rest. They should be placed on foundation walls so built as to make a pit below the centre of machine, into which chips fall, to be removed at convenience. Many of them are used in locomotive shops for boring truck wheels and tire. Numbers of driving boxes also are placed in a circle on the plate and faced off at one operation in an economical manner. The feeds are so arranged as to enable the roughing cut to be made with fine feed, but the finishing cuts with very broad feed, say ⅜ inch to a revolution, to prevent wear of finishing tool (which takes a light depth of cut). N. B.—This is an important item in the economical use of many of our tools.

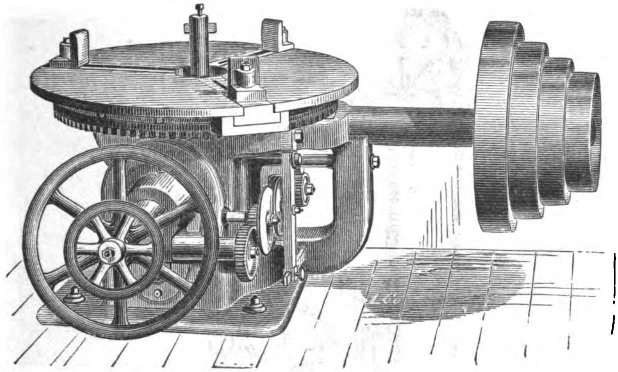
Face plate horizontal. **Foundation.** **Feeds.**

Counter-shaft of 84 inches and 120 inches mill, thus:

Fast and loose pulley on counter 22 inches diameter, 7 inches face, 80 revolutions per minute.

Speed.

FIG. 20.

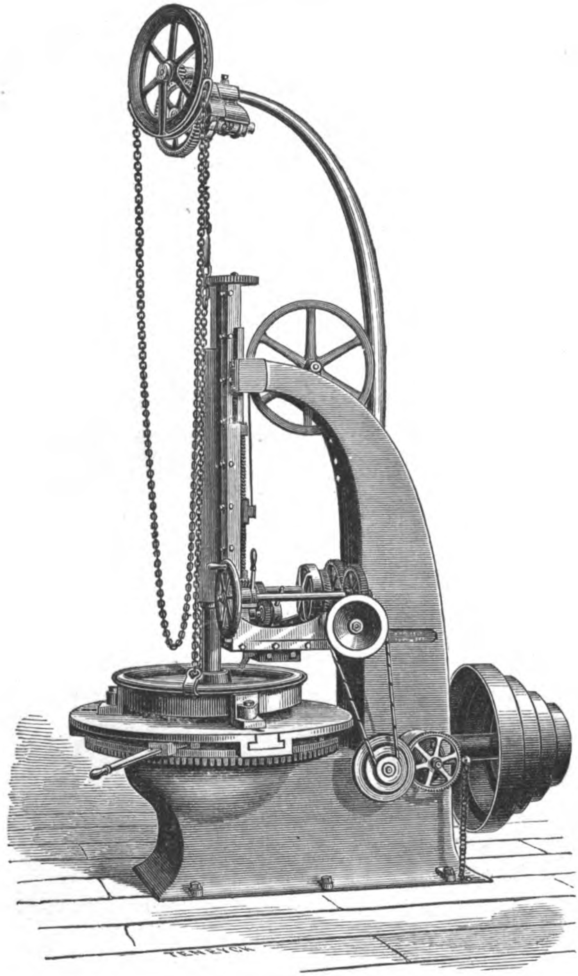


PATENT BORING MILL.

For car wheels and general work, fitted with universal chuck for all sizes up to 36 inches diameter, and capable of boring driving wheels 6 feet in diameter; cross head for holding boring bar counter-balanced and arranged with power feed and quick hand traverse in either direction; the sliding surfaces always clear of chips, which can fall through the face plate as in mills where the bar is supported above; with over-head shaft, iron cone pulleys turned inside so as to be perfectly balanced; ball and socket hangers, and a full set of wrought iron wrenches. Wrought iron work case hardened.

THIS is a useful tool for boring only; is adapted to bore car wheels up to 36 inches in the chuck on the face plate: will bore a wheel six feet in diameter. It uses boring bars with double-ended gib cutters only, the bar being carried by a cross head below the table. The bar must be small enough to **Size of bar.** pass through the hole in wheel before it is bored. Counter-shaft has 24 inches by 4 inches fast and loose pulleys, which should make 60 revolutions per minute; **Speed.** bed of machine must rest on foundation walls, allowing part of the guides for cross head to extend below level of floor.

Fig. 21.



CAR WHEEL BORING MILL.

CAR WHEEL BORING MILL.

For car wheels up to 36-inch, and general work up to 48-inch diameter. Boring bar operated from above; the bearing for bar adjusted vertically. The vertical slide holding boring bar, counter-balanced and arranged with power feed, and quick hand traverse in either direction. The revolving table arranged with universal chuck for all sizes up to 36-inch diameter. In addition to the boring machinery, an adjustable *Hub Facing Attachment* is provided, the slide of which is independent of the boring machinery, so that a hub may be faced off and bored at the same time. Over-head shaft with ball and socket hangers and iron cone pulleys, turned inside, so as to be perfectly balanced; full set of wrought iron wrenches. Wrought iron work case hardened. Fast and loose pulleys, 24 inches diameter for 4-inch belt, on counter-shaft, which should make 60 revolutions per minute.

THIS machine, called also 48-inch Boring Machine, has same face plate, chuck, and means or method of driving as our Patent Boring Mill; but the boring bar is forced down from above into the wheel being bored, and may be larger than in the case of our Patent Mill, Fig. 20. This machine is more efficient, also, and has the advantage of being able to turn off the faces of hubs of locomotive truck wheels. To it we adapt a patent safety crane attachment when desired (see Fig. 21). In boring cast iron car wheels, it is customary to take out the bulk of the metal to be removed, by a double-ended cutter in the boring bar, at one operation, and with a fine feed; then to finish with a very coarse feed, taking out but little metal. This hurrying through of the finishing tool, with but little work to do, insures uniformity of size of hole.

Crane attachment.

For speed see specification above.

Capacity of work may be stated as 50 car wheels in 10 hours. **Capacity.**

Pulley on counter-shaft 24 inches diameter, 4-inch belt, 60 revolutions per minute. **Speed.**

MEMORANDUM FOR BORING CAR WHEELS.

In boring car wheels, assuming the usual size eye, viz., $4\frac{1}{8}$ inches diameter, $6\frac{1}{2}$ inches length of hub, with a core $3\frac{3}{4}$ inches diameter, the mill should be run at

Speed of cut. a speed that will give (12) twelve turns per minute to the wheel, thus making speed of cut about 13 feet per minute. The roughing tool should bore the hole $4\frac{3}{32}$ inches, leaving $\frac{1}{32}$ inch for the finishing cut. The speed of the feed on roughing cut should be 8 to the inch; each end of the cutter having $\frac{1}{16}$ inch feed. At this rate, the roughing cut can be run through in $4\frac{1}{3}$ minutes. The finishing cut should have not less than $\frac{1}{4}$ inch feed, running its cut through in a little over 2 minutes. The two cuts should take

Number of wheels bored. $6\frac{1}{2}$ minutes, or 7 minutes at the utmost. The number of wheels bored per day will depend upon the quickness of the man changing the cutters and shifting the wheels; allowing 5 minutes for changing cutters, facing off hubs, and shifting wheels, 50 wheels should be bored every 10 hours.

Example of work done. At Messrs. A. Whitney & Sons' works, their regular day's work is 60 wheels in 10 hours; but on a trial of speed, one man bored 100 wheels on one mill in 10 hours, or one every 6 minutes. To do this he ran the mill faster than usual, making the cutting speed about 18 feet per minute, and finishing on a feed of $\frac{3}{8}$ of an inch.

Shape of cutters. The cutters are always made double ended, and are turned up square to begin with, thus:

FIG. 22.

Fig. 22.

but as they become dull they are ground off into a shape, thus:

FIG. 23.

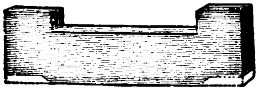


Fig. 23.

and are said to work better after the cutter has begun to be oblique. The finishing cutter, having but little to do, does not wear away very rapidly; in fact, its deterioration depends more upon the time taken to run it through the wheel, than upon the amount of metal removed by it. A fine feed on the finishing cut wears the cutter more than a quick one. The coarser the feed, within reasonable limits, the longer the cutter will remain to size.

Coarse feed for finishing.

The fast or roughing cut will require the cutter to be ground up for every 4 or 5 wheels. The finishing cutter used as above—i.e. with $\frac{1}{64}$ of an inch cut on each end, $\frac{1}{4}$ of an inch feed—will last for 50 wheels with no appreciable change in size. Sometimes cutters have been found that would size 250 wheels with no deterioration. They are always made soft in the middle and hard at the cutting ends. As soon as they show any wear they are stretched to length by paning the soft part in middle of cutter with a hammer. The gauge used for testing the size of bore is a piece of steel like a cutter, made of 1 inch by $\frac{3}{4}$ of an inch steel, ground to the proper size after hardening, thus, rounded to fit the hole narrow way of the ends, so as to be inserted edgeway:

Durability of cutter.

Gauge.

FIG. 24.

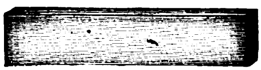


Fig. 24.

Size of axle in "fit." Axles are turned about .007 of an inch larger than the bore of wheel; with the difference of size the force required to push on the wheel is from 20 to 30 tons, and the wheel will not come loose in use.

AWARD OF THE GRAND DIPLOMA OF HONOR AT VIENNA, 1873.

AS a frontispiece we give a reduction by photo-lithography of the Grand Diploma awarded at Vienna in 1873, of which the following is a translation:

WORLD'S FAIR 1873 IN VIENNA.

THE INTERNATIONAL JURY HAVE AWARDED

TO THE FIRM OF

WILLIAM SELLERS & CO.,

IN PHILADELPHIA, PENNSYLVANIA,

UNITED STATES OF NORTH AMERICA,

FOR MACHINE TOOLS,

THE HIGHEST PREMIUM,

THE DIPLOMA OF HONOR.

[The diploma of honor was designed to bear the character of a peculiar distinction for eminent merits in the domain of science and its applications to the education of the people, and the advancement of the intellectual, social, and material welfare of man. Awarded exclusively by the Council of Presidents upon the proposition of the International Jury.]

ORIGINAL:

"*Sellers.*—Wegen besonders hervorragender Leistungen in Erfindung und Fabrikation von Werkzeug Maschinen, die zum Theil den Constructeuren aller Länder als Vorbilder gedient haben."

TRANSLATION.

"*Sellers.*—For pre-eminent achievements in the invention and construction of machine tools, many of which have been adopted as patterns by the constructors of tools in all countries."

PUNCHING AND SHEARING MACHINES OPERATED BY LEVER.

WE have introduced various punching and shearing machines arranged with a heavy wrought iron lever to move the vertical slide. The lever being moved by a cam on the driving shaft. This form of machine we recommend for the following reasons:

It is evident that in all punching or shearing machines driven by a belt, there must be a conversion of the rotary motion of the driving pulley into a reciprocating motion of the punch or shear blade.

Pressure on crank.

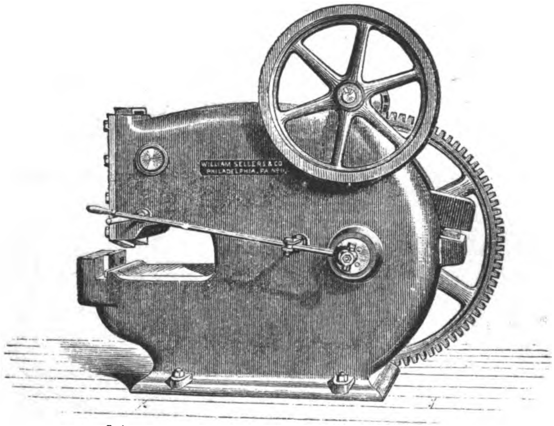
To obtain the requisite power, many revolutions of the driving pulley must occur to one stroke of the punch. In crank machines, the whole pressure of the cut comes directly on the crank pin, which must perform a good portion of its revolution under this heavy strain at whatever speed the crank shaft may be running. This limits the power of such machines to the practical pressure sustainable on a given surface at a given velocity. When the vertical slide which carries the punch is operated by a lever, the sliding motion of the part of the lever in contact with the vertical slide is almost inappreciable: the pressure extends over large surface with little motion; so with the fulcrum pins over which the lever works; with very little and very slow motion of these parts much pressure is admissible, while the long end of the lever is operated upon by the lifting cam acting under comparatively light pressure. Added to this economical use of power, with diminished frictional resistance, comes the possi-

Less friction with lever machine.

Shape of cam. bility of so shaping the lifting cam as to cause the motion of the punch to be uniform through the whole of its stroke, to return quickly, and to dwell during any required portion of the revolution of the crank shaft. So that, in comparing machines using crank and lever, if, in both cases, the same gearing between pulley and work, making the same number of strokes of the same length per minute, be used, there is a capability of punching larger holes when a lever is used than when a crank is employed. The lever punches and shears, as made by us, are provided with a box at back of frame, to hold a block of wood to receive the fall of the tail end of the lever on its quick return motion; the regulation of the height of this block adjusts the length of stroke of the punch in our punching machines, thus enabling it to be set close to the sheet or bar being punched.

Regulation of length of stroke.

FIG 25



SHEARING MACHINE.

Shear operated by a heavy wrought iron lever within the housing. Independent stop motion, so that the blades will rest open; overreach of blades 26 inches; vertical motion of blade 1½ inches.

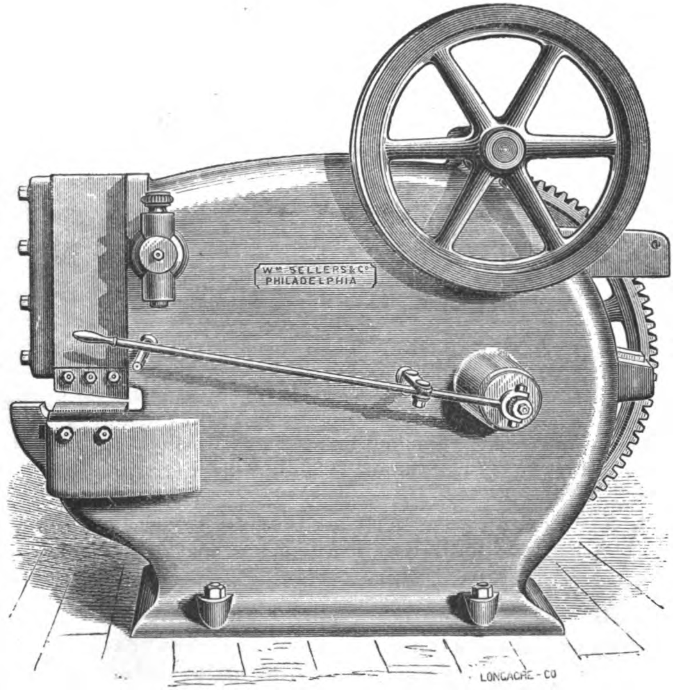
SAME power of machine, also made with an overreach of 33 inches.

For remarks on theory of operation, see page 51, Punching and shearing machines operated by lever.

All that is said in reference to theory of construction holds good either for shearing or punching, as also for speed of pulleys.

Pulley should make 120 revolutions per minute.

FIG. 26.



BAR SHEAR—LEVER PATTERN.

Shear operated by a heavy wrought iron lever within the housing. Independent stop motion, so that the shear will rest at highest point of its stroke; shear blades 9⅝ inches long; will cut 1½-inch by 6-inch iron. Single driving pulley on machine, 36 inches diameter, 7 inches face, which should run 144 revolutions per minute.

BAR SHEAR—LEVER PATTERN.

THIS machine is the same in general principle as the shearing machine and punching machine, pp. 53, 54; with the difference in the arrangement of the fulcrum pin, which is mounted in an eccentric, so as to admit of the adjustment of the same blades for either thick or thin iron. **Adjustment of blades.**

We can furnish dies for rounds if desired, and are prepared to fit the machine with strippers and stops convenient for its use in the smith shop.

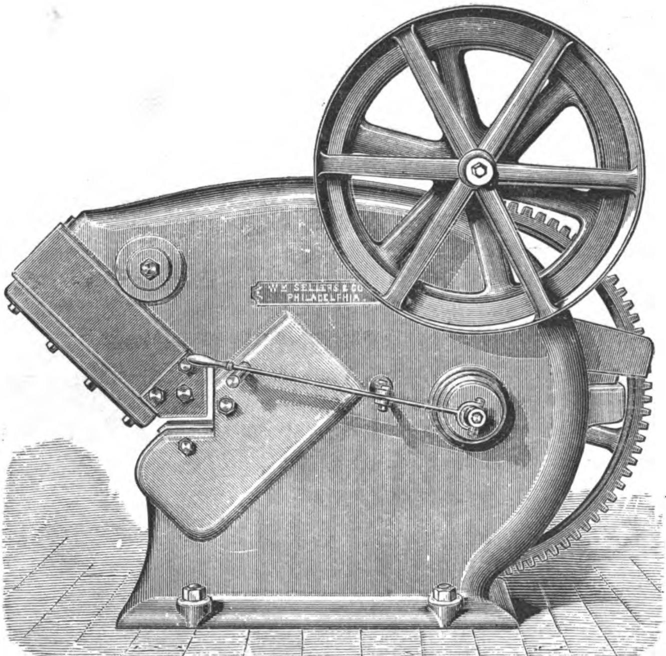
PUNCHING MACHINE (LEVER).

Punch operated by a heavy wrought iron lever within the housing. Independent stop motion, so that the punch will rest at the highest point of its stroke. Can punch a hole in the centre of a plate 52 inches diameter, and has a stroke of 1½ inches.

WE make also similar power of machine with greater overreach; can punch a hole in the centre of a plate 66 inches in diameter.

These machines are being used to great advantage on heavy boiler work and in ship-building operations, and with proper adjustment of size of die to size of punch (see p. 59), the holes for flues may be punched in flue sheets of boilers, ready for the insertion of the flues without the holes so punched being afterwards reamed. The speed of this machine, as also of the shearing machine above, should never be less than 12 strokes per minute; to obtain this the pulley, 36 inches diameter, 7 inches face, should make 120 revolutions per minute.

Fig. 27.



ANGLE SHEARING MACHINE.

Shear operated by a heavy wrought iron lever within the housing. Independent stop motion, so that the blades will rest open; lower blades in two pieces. Fast and loose pulleys on machine, 42 inches diameter, by 7 inches face; speed, 144 revolutions per minute; will shear 6 by 6 inches angles.

ANGLE SHEARING MACHINE.

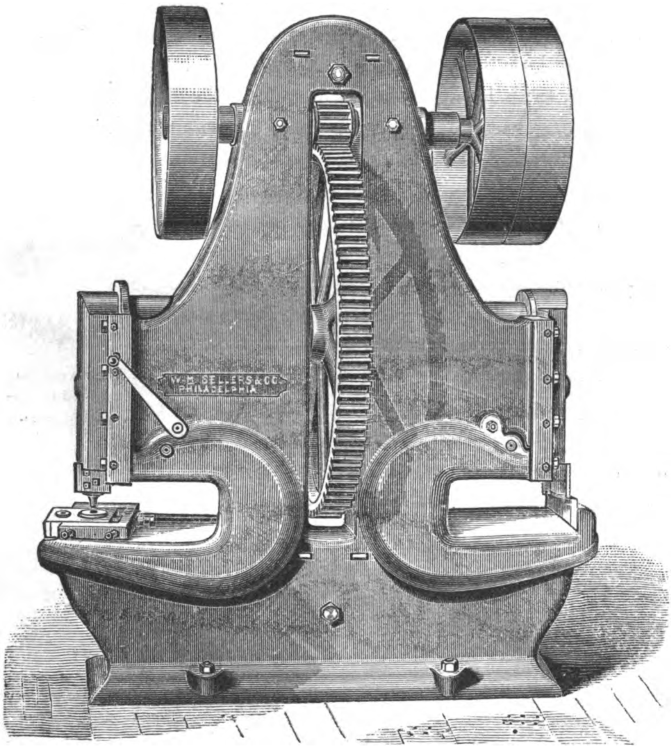
THE same principle involved in all our improved lever shearing and punching machines obtains in this useful tool. Angles which have been curved or bent before shearing and while resting on trussels may be readily trimmed. The blades have no shear given to their edges; but by punching the angle off with a cut extending over all parts of the iron with a uniform pressure, the piece cut off is not bent out of shape. This is an important feature in the machine, as it enables it to be used in cutting up angles to length without distorting the ends cut off.

Does not distort the end.

It will be observed that the design of this machine is similar to our bar shear and our lever plate shear, as shown on previous pages, and indicates the practicability of adapting the frame of these machines to various purposes, as special punches or shears. We can widen the plunger, or vertical slide of the punching machines, and arrange adjustable punches for piercing four holes in fish plates at one operation.

Frame can be adapted to special purposes.

FIG. 28.



PUNCHING AND SHEARING MACHINE COMBINED.

Punch and shears driven from the same shaft; independent stop motion to each, so that they will always rest at their highest point; can punch a hole in the centre, of a plate 35½ inches in diameter, and can shear in width 20½ inches: overreach of jaw 20 inches for rivet punches and shears, and 17¾ inches for washer punches.

PUNCHING AND SHEARING MACHINE COMBINED.

IN designing this machine the requirements of ordinary boiler work were kept in view. The shear is intended for cutting plate iron of usual thickness for boilers; will shear $\frac{5}{8}$-inch plate. The punching side has its dies so arranged in a holder as to permit the punching of flanges of boiler heads which are as small as 12 inches in diameter; the punching being done from the outside or marked side of the head, and flanges turned out on end of flues can be punched vertically. We send with each machine a sample set of punches and dies intended for boiler plate of $\frac{3}{8}$-inch thickness, on which it will be seen that the holes in the dies are made larger than the punches by the following formula, expressing the diameter and thickness in sixteenths of an inch.

Punching boiler heads.

Sample punches and dies.

The diameter of the die hole = diameter of punch, plus $\frac{2}{10}$ the thickness of the plate ($D = d + 0.2\ t$). Thus, for iron plate $\frac{6}{16}$ of an inch thick, the diameter of the punch being $\frac{14}{16}$ of an inch, the diameter of the die hole will be 15.2 sixteenths of an inch,—say $\frac{15}{16}$ inch. This method of making the die hole larger produces a taper hole in the plate, but allows the punching to be done with less consumption of power and, it is said, with less strain on the plate. We do not adapt any strippers to this machine, as the character of work makes it necessary for the users to arrange them to suit their special work. To run these machines efficiently, the fast and loose pulley on the machine should make at least 120 revolutions per

Formula for size of die hole.

No strippers sent with machines.

minute: this will punch 12 holes to the minute; if a faster speed is admissible on the work, the speed of pulleys can be increased. Determine number of punch strokes to the minute, and multiply by 10 for speed of pulleys. By means of the independent stop motion, one stroke can be made at a time on either side of the machine without stopping the machine itself, or interrupting the work being done on the other side. In this respect it is as convenient as two entirely distinct machines.

Speed.

Crank motion punching machine.

We also arrange from same pattern a punch and shear with less overreach; the shear blades placed for cutting off light bar iron, and the punch side arranged for washer punching, or the punching of $\frac{3}{4}$-inch thick bars for car work. When single punches or shears are required, we can stop off part of the frame and produce independent machines, useful for some special purposes, when it is required for convenience to have the punch and shear in separate parts of the workshop.

The punching machine alone arranged in this manner has frequently been used for punching rail ends, and may also be advantageously employed as a washer punching machine.

IN addition to the various machines we have described for punching and shearing bars or plates, we are prepared to furnish

Horizontal punches for fire-box and boiler-head work, convenient also for punching angle irons. We have also arranged some of our punching machines for the plates of coal screens; and to any of the punching machines we can adopt dividing machines to enable the sheets to be spaced mechanically, making proper allowance for the difference of diameter or circumference of outer or inner sheets in cylindrical boiler work.

Horizontal punch.

Automatic spacing.

Very much more rapid work can be done when the plates are moved by a spacing device than when laid out with a template and passed through the machine by hand.

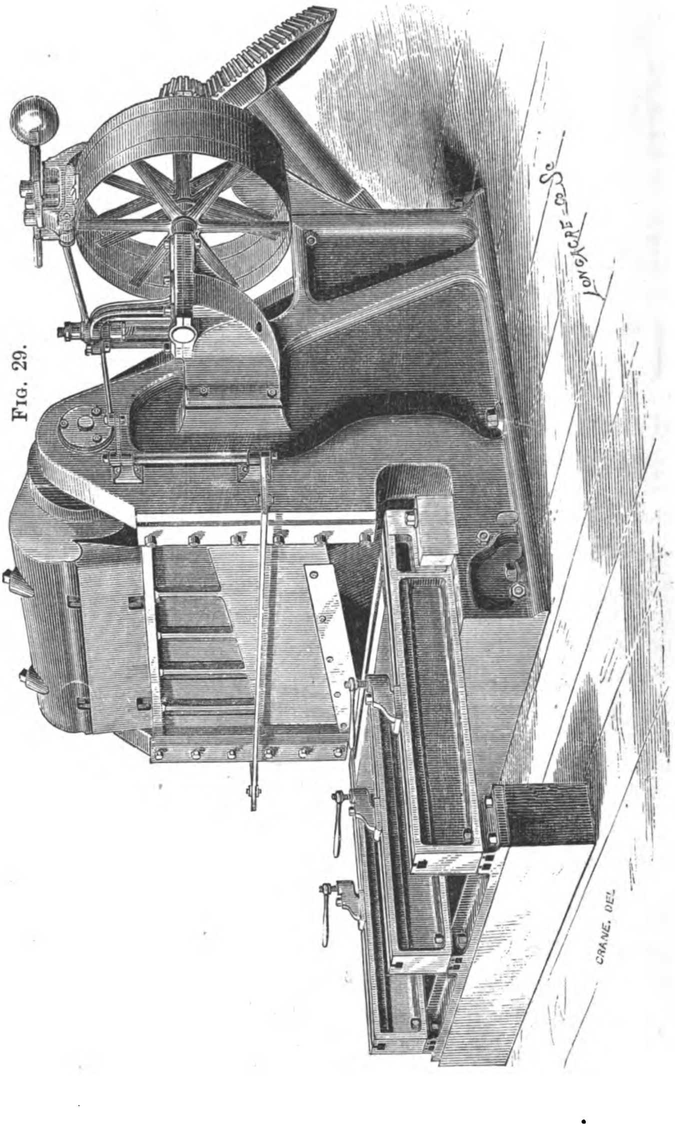


FIG. 29.

PLATE SHEARING MACHINE.

For trimming edges of long plates, or cutting off to length plates 5 feet wide. Will shear wrought iron plates one inch thick. Upper blade guided vertically in the frame of the machine, and driven down by a pitman as wide as the blade is long; this pitman receiving its motion from a long rocking shaft above it. The driving arm or lever of the machine is a rack segment engaging with the teeth of a spiral pinion similar to the spiral pinion used in our patent planers. The spiral pinion is driven by bevel wheel and pinion and open and crossed belt, after the manner of planing machines. Cutting blade adjustable in length of stroke, returning at double the speed of its down stroke. Counter has 24-inch pulleys, 7-inch face, 272 revolutions per minute.

IN designing this machine, the wants of modern bridge construction and ship-building were in view. The plate clamped to place can be sheared with exceeding exactness, either in trimming the edge of long plates or cutting off plates 5 feet wide and under, to lengths. The driving device is new and very efficient. The blade being at all times under the control of the operator, can be made to cut to any fixed point in its length and then stopped or raised. It is provided with an automatic adjustment to its belt-shift motion, gauging the length of its stroke. It makes the down stroke, immediately reascends, and stops up, to wait for the readjustment of the plate. A hand rod in front of the machine is convenient to shift the belts and start the cut.

Driving device.

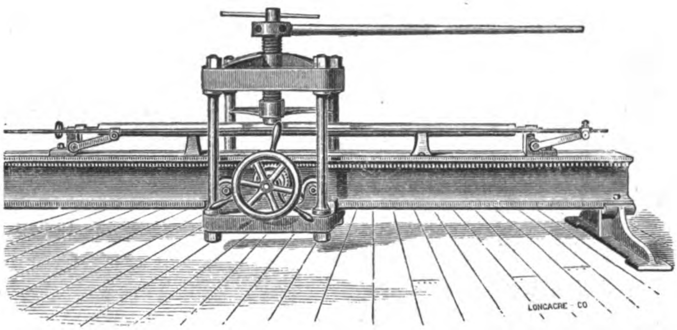
Belt shifter.

The machine is so constructed as to have its strains all within itself, and is not in any great measure dependent upon stone foundations for its rigidity, other than the proper maintaining of the structure in a level position. The vertical slide is arranged to receive curved blades, and the bed plate, to which the lower blade is attached, is capable of ready removal, to receive a curved bed plate with a shear blade bent to match the curve of the upper blade.

Strains.

Curved blades.

Fig. 30.



STRAIGHTENING MACHINE.

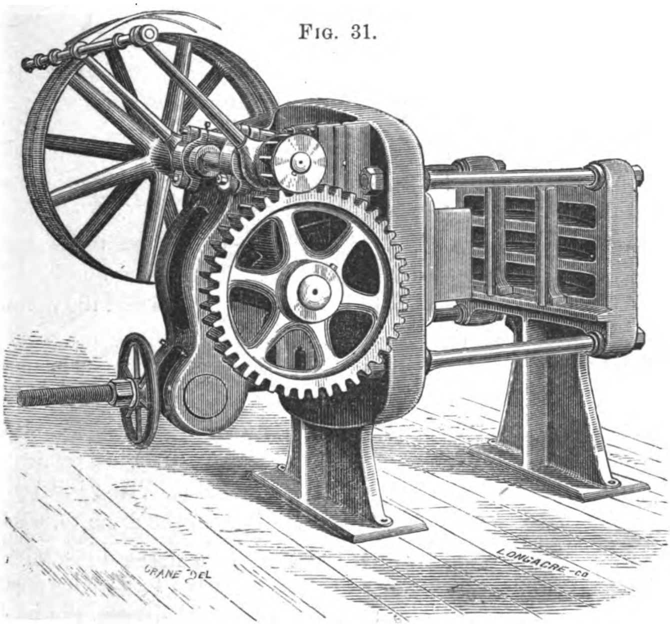
With bed 20 feet long, bending screw traveling the whole length, and the work to be straightened stationary, with centres for shafting to elevate and depress: with a full set of bending blocks; the whole capable of straightening a shaft 6 inches in diameter when cold. Wrought iron work case hardened.

THIS is an indispensable machine in any establishment where shafts are turned. The work having been centred, can in this machine be straightened quickly and thus made ready for the lathes.

In turning long shafts, even when the utmost care is observed, the finished work is almost invariably found to be crooked. This may be caused by the burnishing action of the cutting tool, acting on harder or softer parts of the metal, or by the removal of the scale from the rough iron. Finished shafts can be readily made straight in this machine; it is exceedingly useful, also, in bending or curving iron, other than round; as, for instance, curving T-rails for railroad purposes.

Use in bending rails.

FIG. 31.



POWER STRAIGHTENING MACHINES FOR BEAMS.

Bending plunger working horizontally; driven by a powerful crank with an uniform stroke, but the position of the stroke adjustable; will take in 15-inch beams; can be used for straightening bars, or shapes. Fast and loose pulleys on machine, 36 inches diameter and 7 inches face; speed, 150 revolutions per minute.

BEAMS and other shape irons used on bridge work are most generally handled on trussels during their assemblage into the parts of structure. This machine operates upon the beam as it lies on the trussels, and at a convenient height for sighting.

We make the same kind of machine to be operated by hand when desired.

PATENT HOISTING MACHINES.

WE have during many years made and erected hoisting machines for warehouse purposes. These are arranged to operate with a worm and worm wheel, with driving pulleys on the worm shaft to actuate the machine. The worm wheel and worm are inclosed in an oil-tight box, so that the worm is at all times encased in oil.

Worm and wheel.

Belt shifter.

The belt shaft motion is similar to that used on our planers, and is provided with an adjustable automatic stop motion. This device causes the machine to stop at top and at bottom of the hoistway entirely independent of the motion of the cage, or platform. That is, when enough rope has been carried on to the drum to have hoisted the platform to top of hoist, the machine stops. When enough rope has been unwound to have lowered the platform to the bottom of the hoistway, the machine also stops. This avoids all the accidents incident to unwinding the wire-rope, and afterwards winding up in the wrong direction, when the platform has caught on some impediment in descending, in machines arranged to be stopped by the platform. We estimate for hoisting machines, cages, etc., put up with any of the most improved safety catches, or we sell the machines for millwrights to put in place with such form of cage or platform and safety-catches as they may prefer. We also arrange the same machine as a pavement hoist. We have three sizes :—500 pounds, 2000 pounds, and 4000 pounds. The usual speed of hoist is from 32 to 60 feet per minute.

Automatic stops.

Safety catches.

RIVETING MACHINES.

IN our publications on the subject of power riveting, issued during 1874, we described our Direct Acting Steam Riveting Machine as then made. We have since designed a machine of greater capacity, and have introduced important improvements.

We are also the assignees and sole manufacturers in the United States of Mr. Ralph H. Tweddell's various Hydraulic Riveting Machines, so extensively used in England.

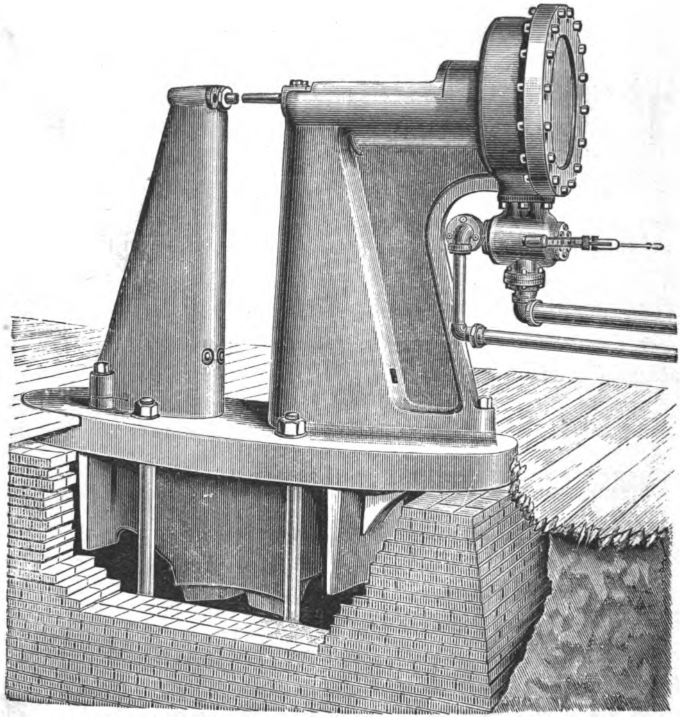
The simplicity of construction of our Steam Riveting Machines, their ready application where steam of the right pressure is obtainable, and their price, recommend them. The hydraulic system above alluded to, however, possesses advantages that abundantly compensate for its cost.

Steam riveting machines are stationary, must be made heavy to withstand the shocks to which they are subjected, and for many kinds of work are not so convenient as a portable machine.

The hydraulic riveter is subjected to no shock when driving the rivet, is much lighter, can be made stationary for boiler or portable for beam riveting, and performs its work with the utmost ease and dispatch.

In submitting the account of our improvements in this class of machines, we deem it advisable to reprint what we originally published on the subject of steam riveting; but in republishing it, with an account of our newer hydraulic system, we cannot help laying stress on the advantages of the latter.

FIG. 32.



STEAM RIVETING MACHINE.

PATENT 72-INCH STEAM RIVETING MACHINE.

Operated by direct action of steam. Piston and riveting ram, wrought iron, in one piece; balanced valve; piston drawn back by expansion of steam used in riveting; upright separate from the bed plate. Can rivet in circular shells, sheets 6 feet wide; can drive all rivets in corners of square fire boxes; also the rivets fastening waist of locomotive boilers to fire box. Tension of steam for driving $\frac{3}{4}$ inch rivets, 60 pounds boiler pressure.

STEAM RIVETING MACHINE.

THE illustration of our 72-inch riveting machine shows our new and improved form of this useful tool. Our 60-inch machine is the same in general appearance, but its uprights are cast in one piece with the bed plate. This form of construction cheapens the first cost and makes a very rigid machine. We have reason to believe that it is strong enough to insure durability. The riveting power of both machines is the same, the chief difference being in the height above bed plate. **60-inch machine.**

REMARKS ON THEORY OF CONSTRUCTION AND OPERATION.

DURING the year 1872 the editor of the *Railroad Gazette*, published in New York, had some experiments tried to show the difference between hand and power driven rivets. His experiments were conducted in Paterson, N. J., the power riveting being done on one of our *60-inch Direct-Acting Steam Riveting Machines.* Subsequently, on August 3, 1872, an article on this subject appeared in the columns of the *Gazette*, which we extract entire.

"DIRECT ACTING STEAM RIVETING MACHINES.

"In presenting a full-page illustration of the steam riveting machine designed and built by Messrs. William Sellers & Co., of Philadelphia, we take occasion to make a few remarks on the principles in- **60-inch machine.**

volved and the practical use of such machines. What is manifestly required in perfect riveting is, that the metal of the rivet while hot and plastic shall be made to flow into all the irregularities of the rivet holes in the boiler sheets, that the surplus metal be formed into heads as large as need be, and that the pressure used to produce these results should not be in excess of what the metal forming the boiler shall be capable of resisting.

Flow of solids.

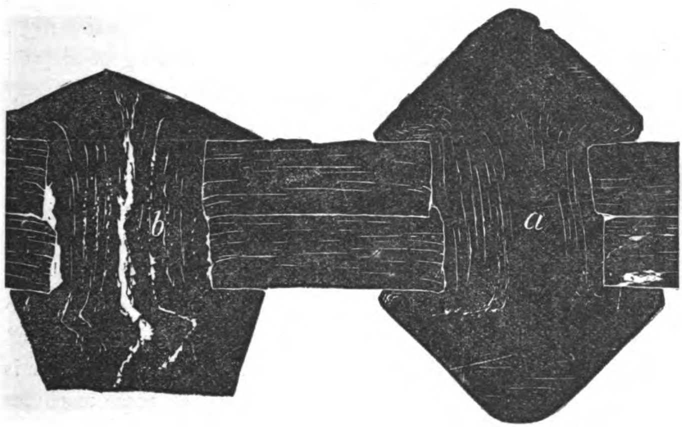
"It is well known that metals, when either cold or hot, if subjected to sufficient pressure, will obey almost exactly the same laws as fluids under similar conditions, and will flow into and fill all the crevices of the chamber or cavity in which they are contained. If, therefore, a hot rivet is inserted into the holes made in a boiler to receive it, and is then subjected to a sufficient pressure, it will fill every irregularity of the holes, and thus fulfill one of the conditions of perfect riveting. This result it is impossible to accomplish with perfection or certainty by ordinary hand riveting, in doing which the intermittent blows of an ordinary hammer are used to force the metal into the holes. With a direct-acting steam riveting machine, however, an absolutely certain and continuous pressure can be imparted to each rivet, so as to force the hot metal of the rivet into all the irregularities of the holes in the same way as a hydraulic ram will cause water to fill any cavity, however irregular. In order to test and also illustrate the relative advantages of machine and hand riveting, we have had two plates riveted together, the holes of which were purposely made so as not to match perfectly. These plates were then planed through the centre of the rivets, so as to expose a section of both the plates

Continuous pressure.

Test.

and rivets. From this an impression was taken with printer's ink on paper and then transferred to a wooden block, from which our engraving was made. *a* was put in by one of Messrs. Wm. Sellers & Co.'s

FIG. 33.



machines, and *b* by hand. It will be observed that the machine rivet fills the hole completely, while the hand rivet is very imperfect. The experiment was tried several times, with similar results each time.

"The hand rivets, it will be observed, fill up the holes very well immediately under the head formed by the hammer; but sufficient pressure could not be given to the metal—or at least it could not be transferred far enough—to affect the metal at some distance from the head. So great is this difficulty that in hand riveting much shorter rivets must be used, because it is impossible to work effectively so large a mass of metal with hammers as with a machine.

Shorter rivets by hand.

The heads of the machine rivets are, therefore, larger and stronger, and will hold the plates together more firmly, than the smaller hand-riveted heads.

"Direct-acting steam riveting machines give a uniform force, if the steam pressure used be uniform, and they give such pressure as is needed, regardless in a measure of the amount of metal forming the rivet. These machines have been made on two general principles. In the English machines, a comparatively light piston of large diameter acting upon a not very large or heavy riveting ram is made to do its work by the pressure of steam alone.* In the machine illustrated, a very heavy piston and riveting ram are made to do the work by the combined effect of steam pressure and momentum. The ram and piston are of wrought iron in one solid forging, and weigh, when finished, over one ton. With the increased weight of the riveting ram a less diameter of steam cylinder is needed. Thus, it is said that one of these machines with a steam cylinder 31 inches in diameter working alongside of an English machine with a steam cylinder 36 inches in diameter does the same kind of work from the same steam boiler, and yet requires a shorter stroke, thus using less steam to accomplish the same result. In practice, it has been found that for locomotive boilers using ⅝-inch rivets about 60 pounds pressure per square inch does the best work.

Weight of ram.

Pressure of steam.

"The machine illustrated is so arranged as to enable all the rivets about the ordinary locomotive boiler to

* The English machine does not do its work without a blow; but, the ram being lighter, its blow is less penetrating; the moving mass is more easily checked. Its increased diameter of cylinder requires a greater expenditure of steam, and is equally severe upon the machine as the smaller cylinder and heavier ram.—W. S. & Co.

be driven with ease; that is, it will rivet the corner seams of the fire box and drive the rows of rivets where the waist joins the outer shell of the fire box. In the practical working of this machine it may be well to mention that the rivets are inserted from the outside of the boiler, not, as in hand riveting, from the inside. The boiler, suspended in slings attached to a crane, is drawn up to the riveting hammer, and the first blow struck carries the boiler, pushed by the rivet head, up to the post, and thus tends to close up the sheets as the head is being formed on the inside of the boiler. The second blow is then delivered with the boiler pressed up to the post or stake, and the steam pressure retained until the rivet has had time to cool. Thus two blows* are given to each rivet; and in this manner, allowing time for each rivet to cool under pressure, five rivets per minute can be driven. The arrangement of valve is such as to enable the charge of steam used in riveting to be utilized in its expansion to draw back the ram."

Drive all the rivets of locomotive boilers.

Method of using.

Two blows to each rivet.

Valve.

To drive rivets by hand, two strikers and one helper are needed in the gang, besides the boy who heats and passes the rivets; to drive each ⅝-inch rivet, an average of 250 blows of the hammer is needed, and the work is but imperfectly done. With steam riveting machine, two men handle the boiler, and one man works the machine; thus, with the same number of men as is required in riveting by hand, five rivets are driven each minute. The superior quality of the work done by

Number of men required.

* More recent practice has shown that two blows are not required: the riveting is well done by one blow, the dies being held shut until the rivet cools. The effect of the second blow is rather to stretch the seam, unless in case of too low steam being used to drive a large rivet. Sixty pounds of steam, driving a ⅝ rivet, should not require a second blow.—W. S. & Co.

the machine would alone make its use advantageous; but to this is added greatly increased amount of work done. In setting up these machines, it is essential

Foundations. that they rest on good substantial foundations, so as to prevent motion of the machine, there being a constant tendency to slide the machine under the impetus of the striking ram. We furnish with the riveter, when

Crane attachment. desired, the necessary over-head rigging of a crane, consisting of sheaves mounted in a carriage, with machinery for drawing the carriage back and forth on rails placed on beams over-head; and for hoisting purposes,

Safety-crab. we furnish a patent safety-crab, which, bolted to the foundation back of the machine, is operated either by hand or power, and is entirely under the control of the man who handles the valve of the riveter. The position and condition of the over-head rigging depend entirely on the character of the work done. When cylindrical work only is riveted, the ways upon which the over-head carriage rests may be in line with the axis of the riveting machine. If much straight-plate work is riveted, the ways should be placed crossways, or at right angles to the axis of machine, and a lateral motion should be given to the ways to adjust them in proper position in reference to centre of gravity of work being riveted and the position of the riveting stake. The riveting machine, as ordinarily constructed by us, is intended for locomotive work especially; but

Will do all kinds of boiler riveting. can as well do all the work on plain cylinder boilers, or on marine boilers. We also adapt, when required, a supplementary riveting stake of steel, upon which flues 10 inches diameter, and in length of 3 feet rings, may be riveted.

HYDRAULIC RIVETING MACHINES.

Cam driven riveting machine.

IN the earliest form of riveting machine, the riveting die was actuated either by a crank or a cam, so that the traverse of the die was uniform, and determined by this driving mechanism. The rivet, whether large or small, long or short, was compressed to the same length, often in rivet holes of varying diameters. Sometimes, therefore, the rivet did not fill the hole; sometimes the plates to be riveted were strained. The work was performed by gradual compression, in itself desirable, but the uniform traverse, operating upon irregular quantities in the rivet, and even forcing the metal into holes of varying capacity, failed to produce regular work.

Steam riveting machine.

The direct action steam riveting machine produces regular work with irregular quantities in the rivet or varying size of holes; but inasmuch as the work is done by a blow, the shock is, in time, destructive to the machine, and sometimes is injurious to the work.

Hydraulic riveting without accumulator.

Hydraulic riveting was first accomplished by a machine on which hydraulic pressure was employed to act directly upon a compressing piston, which carried the riveting die; but in all these hydraulic machines, a pump was employed to produce the pressure in the compressing cylinder, which cylinder was in communication with the pump chamber through a valve which was opened by the fluid whenever the pressure in the pump chamber exceeded that in the cylinder; consequently the compressing piston, which carried the die, was moved only when the pump moved to force

the fluid through the valve, and rested when the pump was taking water for its next stroke. Hence the die might be stationary, while a rivet was but partially headed. Moreover, the compressing piston and die did not move at the will of the operator, but with the motion of the pump, whether it was worked by hand or power. If by hand, the workman had no means of controlling the pressure but by his judgment or strength; if by power, a valve to release the pressure was provided, which could be opened by the operator whenever, in his judgment, a sufficient pressure had been exerted, but no means of determining this with any degree of accuracy was provided in either case, so that, although the pressure was gradual, and the traverse limited only by the performance of the work, the want of means to determine the latter produced irregular results.

Want of means to control pressure.

Tweddell's riveter.

Mr. Ralph H. Tweddell, of Sunderland, Great Britain, is the inventor of a hydraulic riveting machine in which is combined all of the advantages and which avoids all the difficulties which have characterized previous machine systems,—that is to say, his machine compresses without a blow, and with a uniform pressure at will; each rivet is driven with a single progressive movement, controlled at will. The pressure upon the rivet after it is driven is maintained, or the die is retracted at will. And to this combination he adds features not heretofore found in any riveting machine.

Nature of the Tweddell riveter.

This machine consists of a riveting die and a holder, one or the other attached to and moved by a piston in a cylinder, which is called the compressing cylinder; this cylinder communicating with an accumulator through a valve, not self-acting, but moved by the

operator, so that when the valve is opened the piston to which the die or the die holder is attached invariably moves until the rivet is headed, with a force which is positively defined by the pressure on the accumulator. Hence the work is performed without a blow; the pressure is uniform whether the rivets are long or short; it can be modified by the weights applied to the accumulator; it is continuous for each rivet, and may be maintained as long as desired, or the riveting die can be retracted as soon as the rivet is finished, whether the pump is taking water, delivering it, or at rest.

The accumulator above alluded to is an essential part of the system, it is of variable capacity, in it water is kept under pressure, being forced in by means of a pump, or otherwise. The chamber of the accumulator is closed at one end, and to the other end is fitted a stuffing box, through which plays a weighted piston-rod or plunger. This plunger rises or falls as the quantity of water in the chamber increases or diminishes. By varying the load upon the plunger the pressure upon the water in the accumulator cylinder is adjusted. The water or other fluid under pressure on the accumulator, and there stored up ready for use, is conveyed through suitable pipes and admitted by the operating valve to the compressing cylinder of the riveting machine, so that when the valve is opened the water flows into the compressing cylinder, closing the riveting dies upon the rivet, and finishing the work with just such force or pressure as the accumulator has been gauged to produce. **Accumulator.**

The plant required for hydraulic riveting consist therefore of an accumulator that can be loaded so as to give any requisite pressure per square inch; a **Pump and accumulator.**

means of keeping this accumulator full by pump or otherwise; and the riveting machine proper, which may be either stationary or movable within certain limits. For boiler work a stationary riveting machine, somewhat similar in construction to our steam riveters, has its large steam cylinder replaced by a very small hydraulic cylinder. The hydraulic cylinder closes the dies quickly, but without any blow.

Boiler riveting machine.

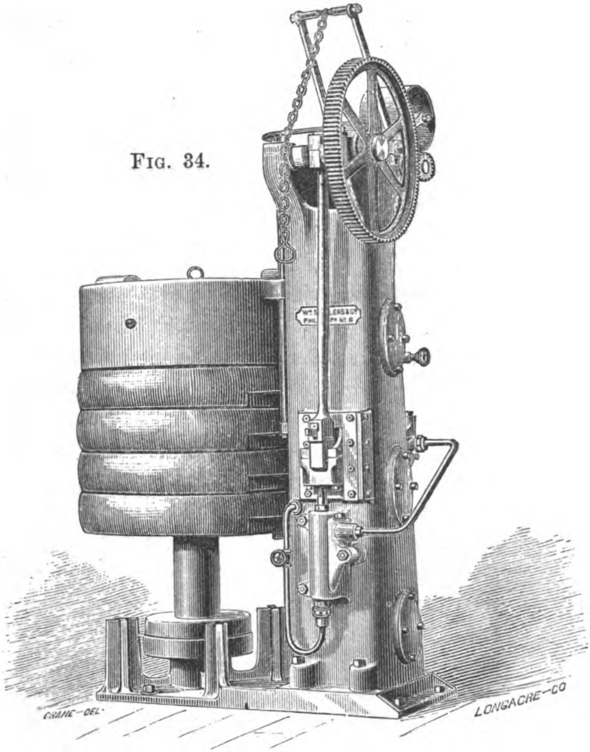
For bridge work construction in the shop,—the pump and accumulator are placed in any convenient position, and the water under pressure is carried through jointed or flexible pipes to a portable riveting machine suspended from an over-head carriage. In using this portable riveting machine the work resting on trussels remains stationary, the riveter is moved along it from rivet to rivet to be driven, performing the work with surprising rapidity and accuracy, and without noise or jar. The whole machine or combination is also arranged for use in the field, by providing a car with boiler, engine, pumps, and accumulator on it, the portable riveter being suspended from a crane or derrick attached to the car. This permits the use of the machine in driving the rivets in bridge erection or in ship building.

Position in shop.

We have secured the control of this valuable invention, and are prepared to furnish the Tweddell hydraulic riveting machinery for any kind of rivet driving.

We have added to the original invention many improvements of our own, pertaining directly to it, and have arranged convenient over-head carriage and hoisting machinery to facilitate the use of the portable hydraulic riveting machine.

Fig. 34.



ADJUSTABLE ACCUMULATOR AND PUMP.

ARRANGED with weights suspended below the main casting, so made as to be readily released from it, to adjust the pressure to the work being done; each weight represents 250 pounds pressure per square inch on the ram of riveting machine. The maximum pressure obtainable when all weights are in place is 2000 pounds per square inch.

The pump, which is double-acting, operated by crank motion, is of improved construction, and takes its water from a reservoir in the upright. The return water in entering the reservoir passes through a mass of sponge to filter it. An important feature in the arrangement of pump and accumulator is the adaptation of our improved relief valve to the system. This valve is so constructed and controlled by the motion of the accumulator as to relieve the pump from work without stopping its motion when the accumulator is full, and to start it to pumping into the accumulator as soon as the accumulator weight has descended a short distance. When this valve is open, the water under pressure in the accumulator is shut off from the pump, and the pump relieved from pressure draws water from the reservoir and forces it back into the same reservoir, maintaining its action without strain, but ready to resume its work when required. When the relief valve is closed, the pump forces water directly into the accumulator. When the accumulator is full, and no water is being taken from it, the pump must either stop or discharge its water elsewhere. To stop the motion of the pump when the accumulator is full, involves its being again started promptly when required, which is not very readily done, and risks the loss of water and entrance of air into the chamber while standing. To maintain the action of the pump and discharge under a safety valve involves the expenditure of power when no useful work is being done. Our arrangement maintains the motion of the pump ready for immediate action, and yet relieves it from strain when not required to do any work.

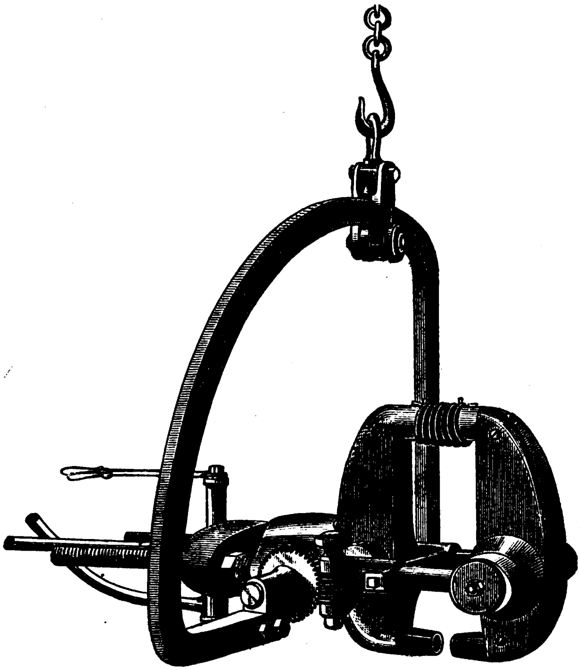
Water filtered.

Relief valve.

Stopping pump.

Discharge under a safety valve.

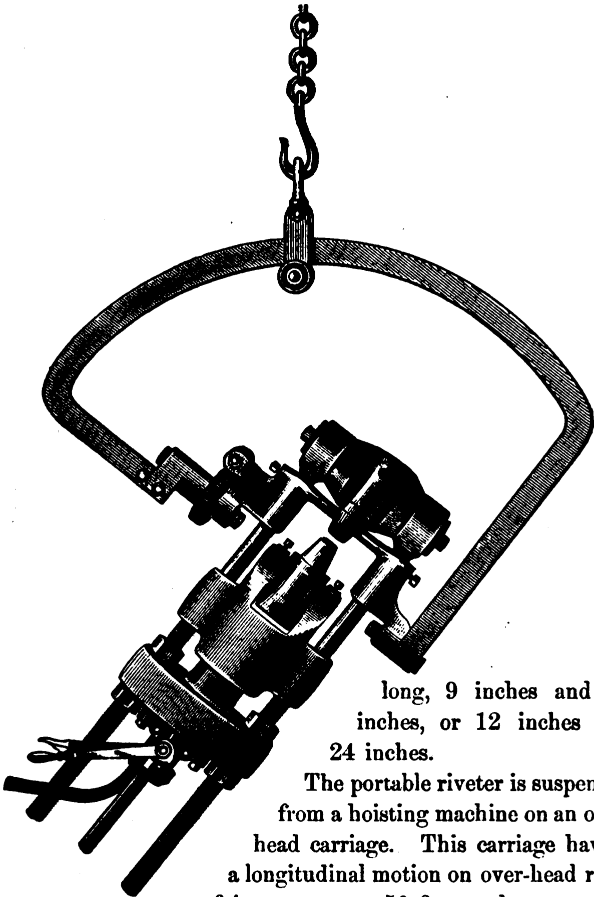
FIG. 35.



THE PORTABLE RIVETING MACHINE.

WE give in Figs. 35, 36, and 37, this useful machine in three positions; showing how it may be adjusted to act readily on seams oblique, horizontal, or vertical. Fig. 35 shows the shape of the riveting jaws or levers. The rivet is driven by the dies in short ends of levers. We make these levers or jaws of various lengths, suited to different work. In all cases the proportion of the two ends is as two is to one. Thus, we make lever 6 inches and 12 inches

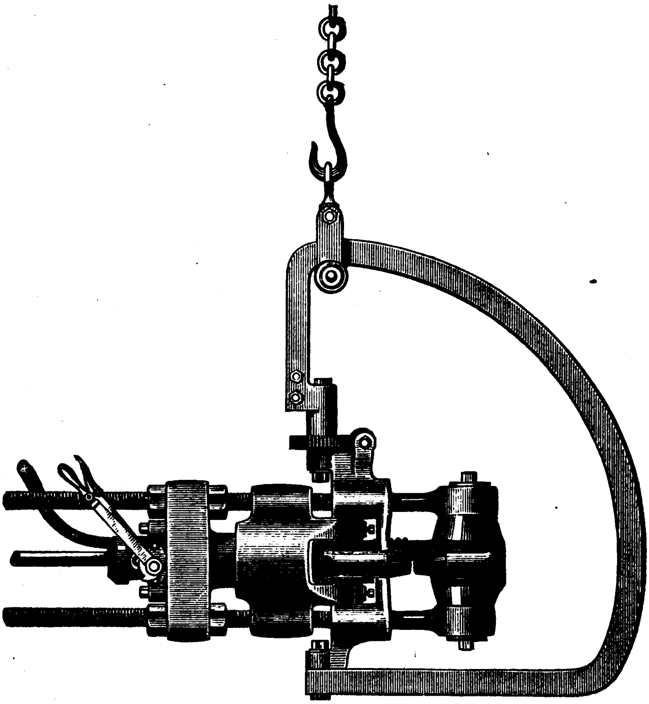
Fig. 36.



long, 9 inches and 18 inches, or 12 inches and 24 inches.

The portable riveter is suspended from a hoisting machine on an over-head carriage. This carriage having a longitudinal motion on over-head rails, of in some cases, 50 feet, and a transverse motion of 6 feet; thus permitting the use of the machine at any point within a space of 50 feet by 6 feet wide.

FIG. 37.



In this space the work rests on trussels and the riveting machine is moved along or around it.

One man raises and lowers the riveter, adjusts it to the rivets, and then closes the dies on the rivets. Boys drop the red-hot rivets into place with the head of the rivet uppermost in horizontal work. With a skillful operator, as many as 6 to 10 red-hot rivets may be put in place ahead of him, and he can, on beam work, drive from 10 to 16 rivets per minute. **Speed of work.**

RIVET HEATING FURNACES.

In using the hydraulic riveting machine to advantage the rivets should be heated rapidly and uniformly. To accomplish this we have arranged furnaces inclosed in sheet iron covers, with every convenience for rapid handling of the rivets by the boys who attend to this part of the work.

OVER-HEAD CARRIAGE FOR HYDRAULIC RIVETERS.

Weston's patent hoist.

THE portable hydraulic riveter is suspended from an over-head carriage; the hoisting machinery of this carriage is one of the improved forms of Weston's hoists, working with very little friction, and capable of nice adjustment of the riveting machine to any position.

1000 lbs. hoist.

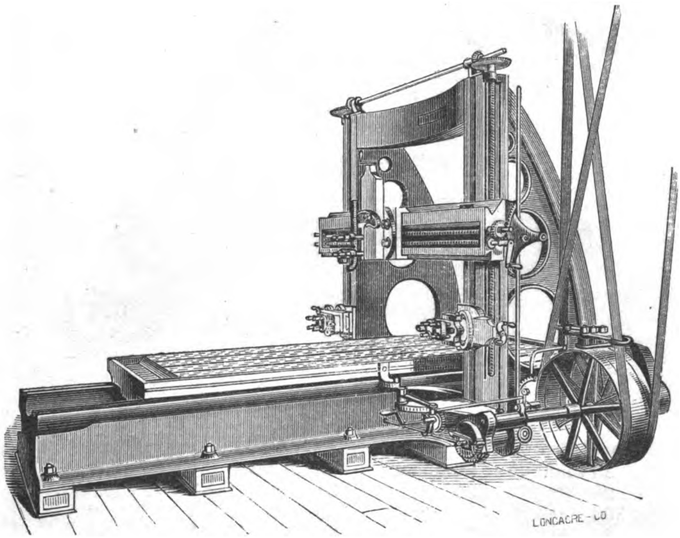
The same carriage with slight alteration can be made to lift 1000 pounds, and, mounted on the same ways as carry the riveter carriage, can be used to lift and adjust the work to be riveted. To obtain the best result with these riveters, the extra hoisting machines are desirable.

Estimate of Riveting plant.

We can estimate for riveting plant when informed of the kind of work it is to be used on, and the character of the building in which it is to be erected.

The hydraulic riveting machinery is inexpensive to maintain, if a very little attention is paid to keeping it in good order. It, like all other hydraulic machinery, should be kept up; not allowed to deteriorate by careless usage. Slight leaks, if stopped by attention to the packing at once, will give no trouble; if neglected, may amount to serious wear from rust and abrasion.

Fig. 38.



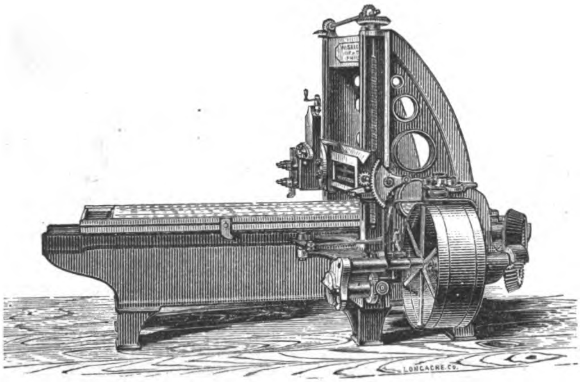
PATENT SELF-ACTING PLANING MACHINE.

For horizontal, vertical, and angular planing of any required length, with spiral gear driving motion; positive geared feeds, self-acting in all directions, with tool lifter operating at all angles, and improved belt shifter.

This machine stands parallel with the over-head driving shaft, thus economizing room in the shop; the bed and table are fitted to uniform gauges, so that the table will work with either end toward the uprights, or on any bed of the same size machine, thus insuring the correctness of the ways.

The over-head shaft is fitted with ball and socket hangers, and the pulleys are perfectly balanced; a full set of wrought iron wrenches accompanies each machine, and wrought iron work is case hardened.

Fig 39.



Name of Planer.	Will plane in width.	In height.	Shortest length of table.
20 inches.	20 inches.	20 inches.	3 feet.
25 "	25 "	25 "	3 " 7 inches.
30 "	30 "	30 "	4 " 2 "
36 "	36 "	36 "	4 " 8 "
42 "	42 "	42 "	5 " 4 "
48 "	48 "	48 "	6 "
54 "	54 "	54 "	6 " 7 "
60 "	60 "	60 "	7 " 3 "
72 "	72 "	72 "	8 " 6 "
84 "	84 "	84 "	10 "
120 "	120 "	120 "	13 " 6 "

These machines can be of any required length.

PATENT SELF-ACTING PLANING MACHINE.

THIS machine, differing in so many particulars from planers as heretofore made, has proved itself so durable and efficient as to have attracted the attention of all the principal users of such machines. The editor of the *Practical Mechanics' Journal*, London, in commenting on the machine

tools exhibited in the Paris Exposition of 1867, begins an article on "American Planing Machinery":

"Amidst the countless machine tools exhibited last year in Paris by every foremost maker in every prominent nation in the world, there were none so remarkable for the breezy freshness and originality in the conception and carrying out the contrivance of various parts, by which the combined action of each machine tool as a whole was obtained, as those produced in the United States divisions by Messrs. William Sellers & Co., of Philadelphia." We here reprint the substance of the description of these machines, as given in that journal, adding such remarks of our own as may assist in a full appreciation of the merits claimed for this tool:

"Most conspicuous and important among the various novel features of this machine is the manner of giving motion to the table; this is furnished with a rack, but instead of being operated by the ordinary spur gearing, it receives motion through a peculiar form of spiral pinion upon a driving shaft which crosses the bed diagonally, and passes out in the rear of the upright, on the side where the workman stands. This shaft is driven from the pulley shaft by means of a bevel wheel and pinion. The position of the pulley shaft places the driving belts within convenient reach of the operator; and its axis being parallel with the line of motion of the table, these machines may be placed parallel to lathes, and thus economize space and permit a better arrangement of workshops. By this simple driving arrangement a very smooth and uniform motion is imparted to the table; the pinion has four teeth, and is, in fact, a short piece of a coarse screw, the position of the teeth upon the same being

See Figs. 40 and 41, Pages 88 and 90.

Driving the planer.

Machine stand parallel with lathes.

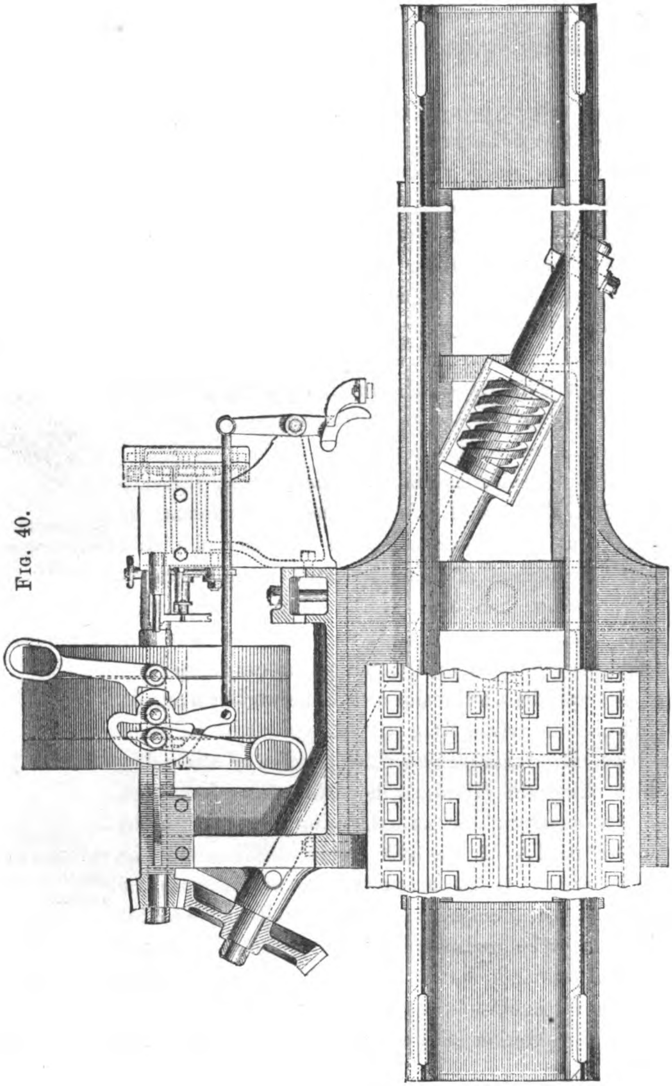


FIG. 40.

as the threads of a screw of a steep pitch, and of a like number of threads to that of the teeth in the pinion. This pinion being placed upon the diagonal driving shaft, its action differs from that of an ordinary spur wheel, as it also does from that of a worm; that is to say, if the driving shaft were at right angles to the rack, the pinion would be the ordinary spur; but if it were inclined to the rack, say 5°, the teeth of the pinion would require to be slightly curved, and would commence driving at one side of the rack, shifting gradually to the other as it revolved. The same process takes place at any other angle, the sliding cross motion being more rapid the greater the angle from the perpendicular, until it reaches 90°, when it becomes a worm, and the teeth of the rack would then require to correspond with the angle of the thread. With the present arrangement, however, the teeth of the rack must be straight, but may be placed at any convenient angle to the line of the rack. Although the teeth of the latter are straight, and those of the pinion curved, the surface of contact and wear upon the rack is not limited to a small central portion of its teeth, but uniformly distributed over the whole width of the rack.

Action of the spiral pinion.

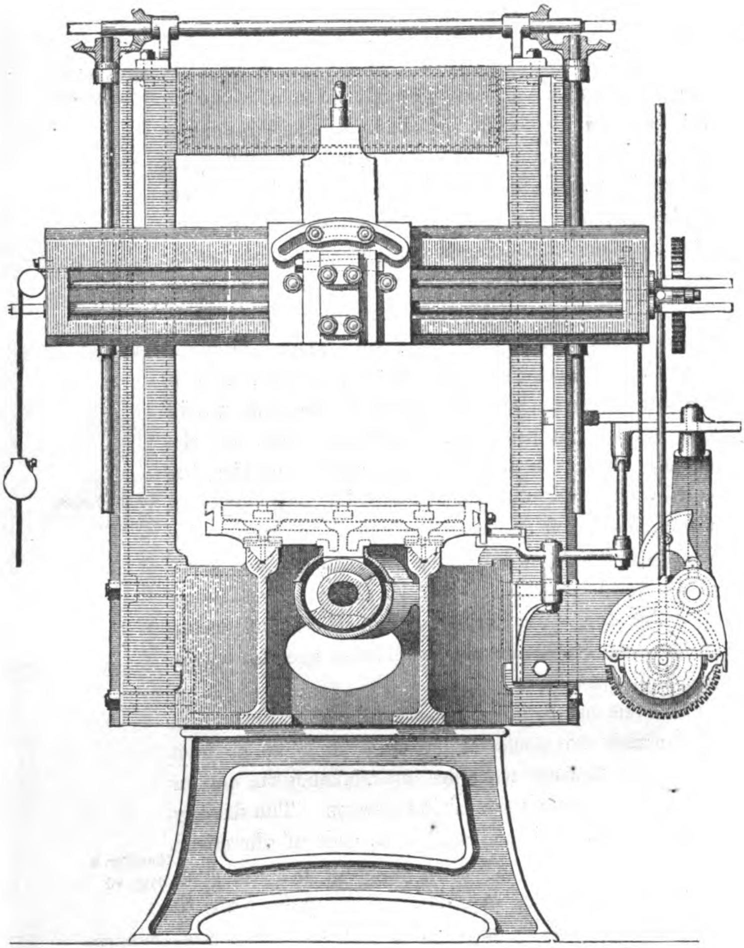
Teeth of rack straight.

"In the arrangement we are describing, the teeth of the rack are placed at an angle of 5° to its line of motion, to counterbalance any tendency the pinion might have to move the table sideways. The driving shaft revolves in bearings at both ends of the spiral pinion; these bearings are cast in the bed and connected by a trough surrounding the pinion, which trough is covered by caps under the rack, thus preventing chips and dust from reaching the pinion; the oil placed upon these bearings can escape only into

See Fig. 41, Page 90.

Pinion protected from dirt.

Fig. 41.



this trough, and furnishes sufficient lubricating material for the pinion and rack.

"It is a mistake to suppose this pinion must run in oil; in fact, such a condition of affairs would be highly injurious, as the oil would be thrown off by the revolution of the pinion, and would become a serious nuisance. The thrust upon the driving shaft from the motion of the table under cut is received against a step-bearing in front, and the lesser thrust during the quick return motion is received against hardened collars at the other side of the spiral pinion.

Oiling the pinion.

Thrust of pinion shaft.

"It will be noted that the sides of the bed directly between the uprights are very firmly braced by a box-shaped connection, the diagonal driving shaft not interfering with it, thus strengthening the most vital part of the machine, as is the case in most of the ordinary forms of planers; the same space being in some rack planers occupied by the gearing, while in the screw planer the height of the cross braces must be much diminished to give room for the screw and nut.

Bracing in bed.

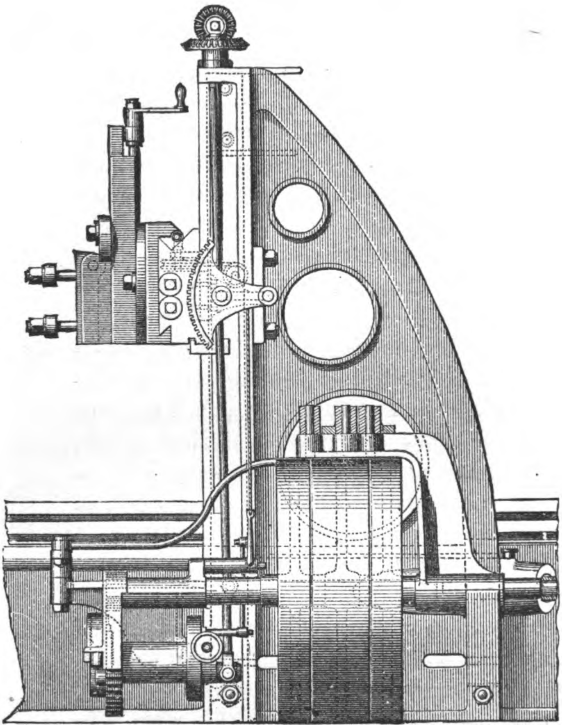
"The disposition of the driving shaft and gearing in this machine may also be looked upon as an improvement over the frequently adopted plan of placing the driving gear and pulleys in front of the uprights, on the side of the machine opposite to the attendant; in which position these parts and the belts are apt to interfere with the planing of pieces overhanging on that side of the table, and are out of the reach of the operator. The transmission of motion to the table from a high speeded belt is accomplished by a single pair of bevels, the largest one of which may be easily made of such diameter, relative to the pinion, as to give the required reduction of speed and

Position of belts as regards workman.

See Fig. 40, Page 88.

Bevel wheel.

Fig. 42.



transmission of power without the intervention of other gearing. This arrangement has evident advantages over the ordinary screw planer, in which the gearing at the end of the screw is limited in size by the table projecting over the ends of the bed. The device for shifting the belts in the Sellers' planer is

Belt shifter.

another peculiarity worthy of notice; it consists of a curiously shaped lever, vibrating horizontally upon a fulcrum pin placed between the fulcrums of the two belt shifters; the whole being supported upon an upward extension from the cap of the rear bearing of the pulley shaft. The middle arm is provided on opposite sides with an internal and external projection or tooth, these teeth meshing with corresponding notches and projections on the respective shifters; the teeth upon the middle lever are relatively so disposed that the motion of one shifter is effected and completed before that of the other is commenced, which arrangement combines, with the least possible lateral motion of the belt in shifting, the important advantage of entirely removing the one belt from the driving pulley before the other commences to take hold to reverse its motion. The shifting is thus effected with very little power, and the shrieking and undue straining of belts avoided.

See Figs. 40, 41, Pages 88, 90.

"The variation of stroke of the table is obtained by means of the usual adjustable stops on the side of the table, which stops actuate the above-described shifting device by means of a double-armed lever and link connection. This lever and link are in the most convenient position for changing the position of the belts independent of the stops, so that the workman can with great facility control and reverse the motion of the table by hand in setting the tool or in planing over intervening irregular lengths; he can also set both belts on the loose pulleys, and thus at any point arrest the motion of the table without stopping the counter-shaft.

Length and adjustment of stroke.

"Several novel features are also introduced in the feed motion for the cutting tool, and in the devices

Feed.

Fig. 43.

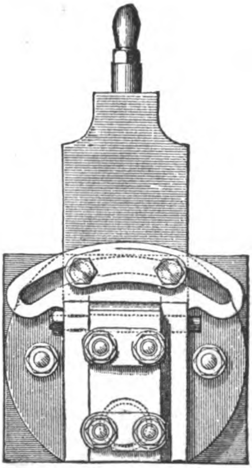


Fig. 44.

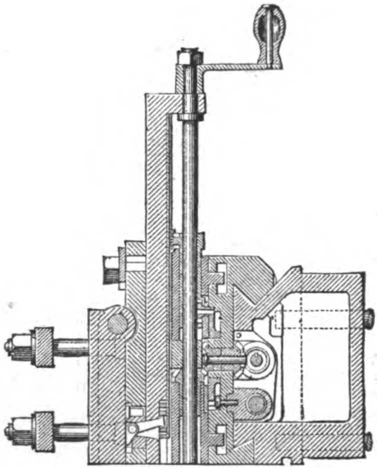
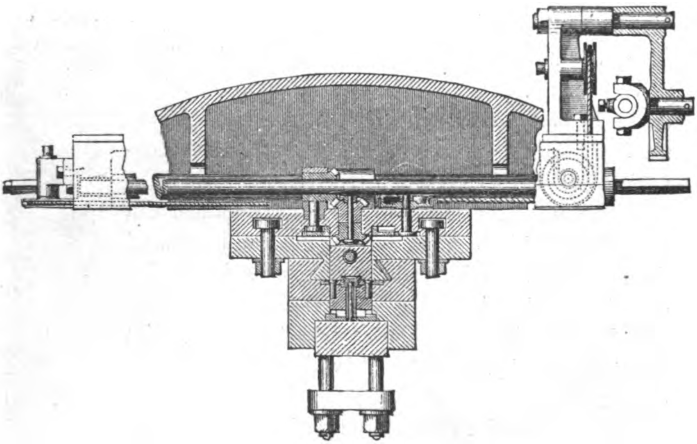


Fig. 45.



for elevating the cutting tool during the return stroke of the table. The usual screw and central feed shaft are provided in the cross head for transmitting either a horizontal or vertical feed motion to the planing tool in either direction; they receive a variable amount of motion for any required amount of feed through a ratchet wheel, fitted interchangeably to their squared end projections at the front end of the cross head, where the ratchet wheel is actuated by a toothed segment, which receives at each end of the stroke the required alternate movements in opposite directions from a crank disc below by means of a light vertical feed rod. The crank pin on the feed disc below is so arranged that its throw and amount of feed can be conveniently varied and adjusted during the cutting stroke of the table, while the machine is in motion.

FIG. 46.

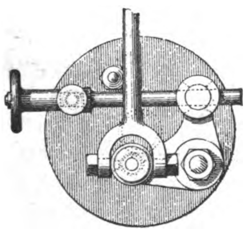
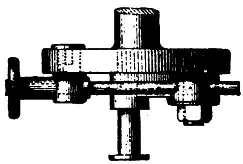


FIG. 47.



By means of an ingeniously contrived double pawl and ratchet wheel, deriving motion from a pinion on the front end of the pulley shaft, the crank plate is at each reversion of the stroke alternately moved a half revolution, and disengaged in either direction; friction is only employed to throw the pawl into gear at each change of motion, whereupon a positive motion of the crank disc is kept up by the ratchet wheel until the pawl is disengaged from the teeth of the ratchet wheel See Figs. 41, 48, and 49, Pages 90, 96.

FIG. 48.

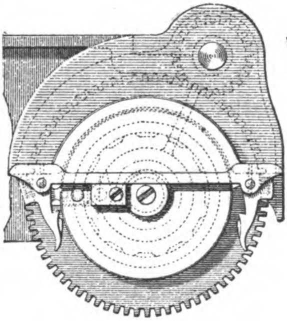
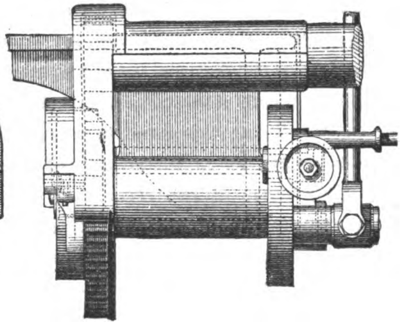


FIG. 49.



Comparison with other methods.

by a positive stop. In nearly all planing machines the feeding motion of the cutting tool is obtained from the belt-shifter, which is actuated by stops upon the table, as described; such an arrangement entails an undue amount of work upon these stops, whilst the variations of feed obtainable in this way are quite limited; besides which, under many circumstances, it will be found necessary to make the feed under the cut, as the feed motion will be always actuated at the end of the stroke before the motion of the table is reversed, whilst in a feed motion actuated from the gearing the motion will always be produced at the beginning of the stroke, and the amount of feed to be obtained in this way is practically unlimited. In nearly all modern planing machines the cutting tool is hung in what is called an apron, so adjusted as to allow the tool to swing loose on the back stroke of the planer table, but to be held rigidly when cutting. In large planers when the weight of the tool is great, and in all fine planing, this liberation of the tool is not sufficient of itself, but va-

Feed.

See Figs. 43, 44, and 45, Page 94.

Apron.

rious arrangements have been added, whereby the tool point can be actually lifted clear of the work on the back stroke, and dropped into place ready for the cut, after the article to be planed has passed under it; but perhaps none of these contrivances are so completely applicable as this one for lifting the tool in every position of the slide rest, and to do so from within the cross head, without interfering with any of the machinery for working the feeds, which occupy the centre, about which the adjustable part of the saddle rotates." **Lifting tool point on back motion.**

To this may be added that recent experiments seem to demonstrate that the great durability of the spiral pinions and rack used in driving these machines, is due to the fact that the action of the teeth is more a rolling action than a rubbing or sliding one. The ways or V's in the bed are provided with oil dishes at each end to retain the oil used in lubricating them, and the planer tables have self-operating oil scrapers, which, during the motion of the table, distribute oil uniformly over the surface of the ways. Planers up to 36 inches capacity, inclusive, are arranged with legs or feet to rest on the floor, but all larger sizes are intended to be placed on foundations; and it is recommended that they be set upon stone sills crossing the bed at each pair of foundation bolt holes, so as to prop up the machine to the required height, and to permit the ready removal of the chips that may fall inside of the bed. **Durability.** **Oil dishes.** **See Fig. 40, Page 88.** **Legs.** **See Fig. 41, Page 90.**

We name in our schedule of prices the shortest length it is possible to make these machines, and then give the price per foot for extension of table; and in the tabular lengths given the distance is measured from the centre of the cross dishes at each end of table, and not of the actual length of plane surface **Length of table.**

of table. We do this because, be the length of table what it may, if the work bolted to the table is stiff enough to overhang these dishes, it can be effectively operated on by the machine.

Erecting the machine. In placing these machines, it is of the utmost importance that they be carefully lined up when being put in place. On the larger sizes of planers we arrange vertical slide rests, attached to the uprights and operated by independent feeds, to enable work to be planed on the sides or edges at the same time that the surface is being planed.

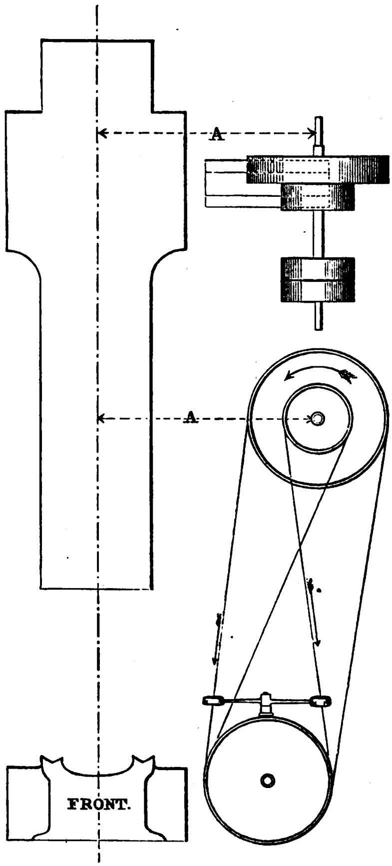
Vertical slide rests on uprights. These are either adapted to one upright or both, as may be required; and, in case of one only being used, we place it on the working side of the machine,—*i.e.*, on the upright next to the driving pulleys. These vertical slide rests are capable of being lowered below the surface of the table, so as to be entirely out of the way when not required. On locomotive work especially, these vertical slide rests are of great use.

Two saddles on cross head. Two saddles are sometimes required on the cross head of planers of 36 inches capacity and over, to enable two cuts to be taken at the same time on the surface of work; they are so used in locomotive shops for planing frames and guide bars. When two saddles are adapted to any machine they are provided with a convenient method of moving them sideways, by hand, independent of the regular feed motions.

Placing the counter-shaft. Some care must be taken in placing the counter-shaft so as to insure the belts passing through the belt forks in the best position; to facilitate this setting, we send with each machine the following table:

See Fig. 50, Page 99.

Fig. 50.



PLAN AND ELEVATION.—Showing Bed of Machine and Position of Countershaft.

DIRECTIONS FOR LOCATING THE COUNTER-SHAFTS OF WM. SELLERS & CO.'S PLANING MACHINES.

SMALL pulley on counter-shaft drives planer FORWARD, with a CROSS BELT.

LARGE pulley drives BACKWARD, with an OPEN BELT.

The counter-shaft must be set for each machine as per following table, to allow the belt shifters to throw the belts properly.

In no case can the centre of counter-shaft be vertically over the centre of pulley shaft on machine.

Name of Planer.	Counter-Shaft.			Distance *A* from centre of bed of Machine to centre of Counter-shaft.
	Speed.	Diameter and Belt of Fast and Loose Pulleys.		
20″	300 rev.	8″ Diam.	4″ Belt.	$27\frac{1}{2}$″
25″	256 "	12″ "	4″ "	35″
30″	236 "	14″ "	4″ "	$41\frac{1}{2}$″
36″	220 "	16″ "	4″ "	$47\frac{7}{8}$″
42″	209 "	18″ "	6″ "	$52\frac{7}{8}$″
48″	228 "	18″ "	7″ "	58″
54″	228 "	18″ "	7″ "	61″
60″	207 "	20″ "	7″ "	$69\frac{3}{4}$″
72″	198 "	22″ "	7″ "	$78\frac{1}{2}$″
84″	190 "	24″ "	7″ "	90″

MARCH, 1871.

The 72-inch and 84-inch Planing Machines are provided with means of raising the cross head by power.

The above table refers to a cut given on page 99, Fig. 50.

FIG. 51.

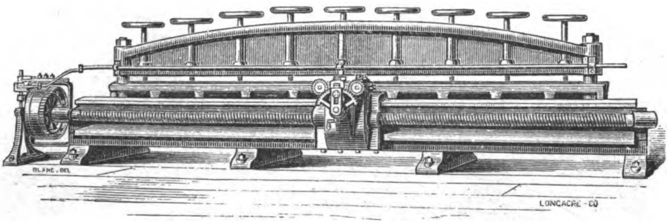
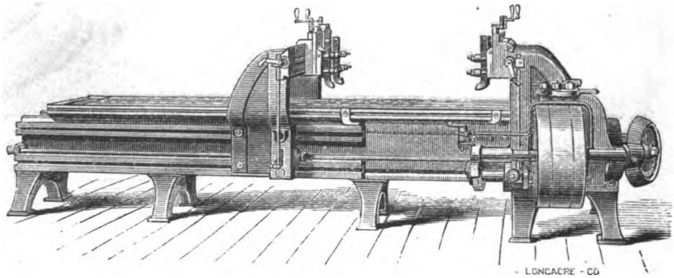


PLATE PLANING MACHINE.

Arranged with table to carry plate 14 feet long, with powerful holding-down bolts, clamping the sheet on a wooden bolster, which may be curved to form of ship plates. Cutter head driven by screw, carrying two tools, taking cut both ways and self-operating in feed.

IT has been found that boiler plates, planed to a bevel on their edge, can be worked with more certainty and make much better work at a very much less cost than if chipped by hand. It was thought that the same result might be obtained by using bevel shears which should cut the edge on an angle, but the work done by them was found to be so ragged as to be practically worse than if left square. The Plate Planing Machine bevels the edge and squares up a narrow calking surface. For building iron ships this machine is invaluable, it being able to plane the sheets either before or after being bent. **For ship work.** Fast and loose pulleys on counter 12 inches diameter, 4 inches face, speed 373 revolutions per minute. **Speed.**

FIG. 52.



ROD PLANER.

For planing locomotive connecting rods, arranged with two sets of uprights and cross heads, with double saddle on each cross head. Table driven by patent spiral driving gear, so arranged as to move table at same speed each way, and, taking cut in both directions, is adjustable in length of rod to be planed from 3½ to 10 feet. Self-operating feed to saddle. Will plane both ends of two connecting rods at the same time. Fast and loose pulley on counter-shaft, 14 inches diameter, 4 inches face, should make 236 revolutions per minute. Ball and socket hangers for over-head shaft; wrought iron work planed to standard sizes and case hardened.

A SPECIAL tool designed for use in locomotive shops; useful in planing the ends of connecting rods, but is applicable to all kinds of stub-ends for stationary-engine work as well; can also be used for planing guide bars for locomotives, in which case it will work to advantage on four guide bars at once. It is a solid, substantial tool, capable of taking **Spiral pinion.** same cut as our regular 30 inches by 30 inches planer, and has all the advantages of our patent planing machine. In using this machine for a long time on short

strokes it is advisable (as with any planer) to pay more attention to the oiling of the V's than if it was on long work, as at short strokes the oil is not so well distributed by the self-oilers; so an occasional examination of the spiral pinion, to see that it is greasy (not slushed with oil), is advisable. **Oiling the ways.**

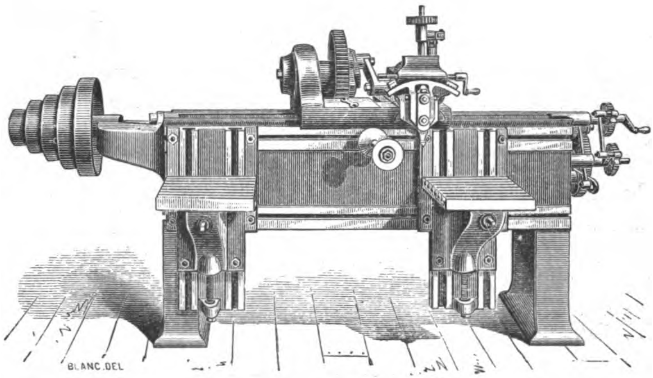
The introduction of this machine has materially cheapened the production of locomotive connecting rods and similar work. Speed of counter same as for 30 inches by 30 inches planer, viz., 236 revolutions of fast and loose pulleys, which are 14 inches diameter, 4 inches face.

SLABBING MACHINE.

Arranged with bed, tables, and uprights, like planer, with a capacity of 25 inches by 25 inches; table 12 feet long. Table operated by spiral pinion in same manner as on our patent planing machine. Spindle to carry cutter 4½ inches diameter, 4 inches wide, powerfully geared, and adjustable in height.

THIS tool is especially adapted to mill the flats of connecting rods and similar work. When used for cutting cast iron, larger cutters than 4½ inches diameter can be used to advantage. The feed is variable between the extremes, and the table has a means of moving it readily by hand, with an automatic stop motion to throw out the feed at the end of the stroke. The table is provided with a dish extending entirely around its edge, to catch the water used in cooling the cutter. The fast and loose pulleys on the machine are 20 inches diameter, 3 inches face, and should make 114 revolutions per minute. **Variable feed.**

FIG. 53.



SHAPING MACHINE.

With shaping bar moved by variable crank, with quick return motion; feeds self-acting in all directions; self-acting motions for straight, curved, vertical, and angular work, and internal curves; the planing tool moving in every direction, and the work stationary. Tool holder, with segment wheel and worm, two tables for holding the work, adjustable, longitudinally and vertically, two arbors, two pairs of cones; over-head shaft, pulleys and ball and socket hangers; cone pulleys, turned inside so as to be perfectly balanced; a full set of wrought iron wrenches, and all wrought iron work finished to standard sizes and case hardened.

With stroke of bar 9 inches to plane, in length 36 inches.
" " " 12 " " " " 48 "
" " " 16 " " " " 66 "
" " " 20 " " " " 84 "

Centre head on bar with index plate.
Clamping vise.

THE shaping machine, called sometimes compound planer, is one of the modern machine tools of such great convenience and universal application that it has become essential even in shops of limited

capacity. The manner in which it performs its work—viz., the work being stationary and the tool held on the end of projecting bar being made to move—involves conditions requiring unusual care in design and construction.

Work stationary.

The peculiar device invented by Mr. Whitworth, of Manchester, England, and first applied by him to these tools, of so arranging the driving crank motion as to give a slow motion of tool under cut and a quick return, has come to be universally acknowledged as the proper means of operating the planing tool. Our shaping machine has this so-called Whitworth motion, constructed in such a manner as to make the cut in about two-thirds of the revolution of crank wheel and the return stroke in the remaining one-third of a revolution. We have retained all the essential particulars of the machine as made by Mr. Whitworth and added many conveniences, adapting it to a wider range of work, increasing its power of cut, and so arranging the driving power and feed as at all times and in every motion to insure the feed occurring at end of stroke, and never under cut. This is an important feature. The machines, when built, are submitted to rigid examination and tests to be sure that they plane true in square and in parallelism, errors being more apt to creep into this class of tools than in any other, so that users will find that the extra cost required to produce a machine which is correct in adjustment and in work is amply compensated for in excellency of performance. The counter-shafts of these machines are each arranged with two speeds, one fast one for short work, and one slow one for greater length of cut, and for planing steel. These differences of speed are in addition to the changes incident to the cone pulleys.

The Whitworth motion.

Quick return to tool.

Feed always at end of stroke.

Inspection of tools.

Speeds.

Counter-shaft. Our 9-inch shaping machine has on its counter 6 inches by 2½ inches fast and loose pulleys, which should make 400 revolutions per minute, and a pair of 10 inches by 2½ inches fast and loose pulleys, which should make 150 revolutions.

Speed. Our 12-inch machine has 8 inches by 3 inches, fast and loose, 300 revolutions, and 14 inches by 3 inches, fast and loose, which should make 100 revolutions.

Our 16-inch machine is provided with 10 inches by 4 inches, fast and loose, to run 380 revolutions, and 18 inches by 4 inches, fast and loose, to run 135 revolutions.

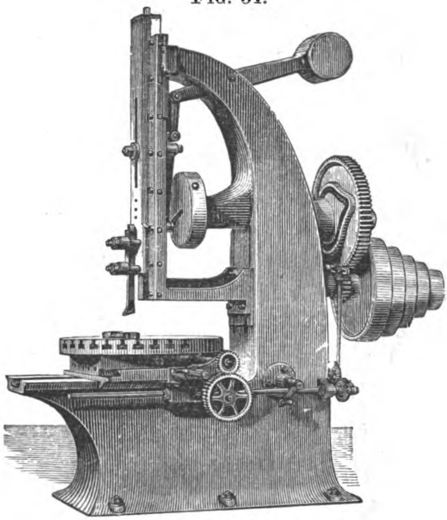
Clamping vise. We also make clamping vises, adapted to each size of machine, for the convenience of holding many kinds of work; but in large establishments, where there is a repetition of planing on the same kind of work, it is customary for the user to adapt to his work special holding devices.

Spindle for curved work. The machines are provided with a spindle and chucking cones, for doing circular work, such as planing up the bosses or hubs of rocker arms, but in addition to this much work can be more conveniently held in independent centre heads. (Centre heads.) We arrange centre heads for each size of machine, with index plates carefully divided, and with tangent wheel and worm for feeding on circular work. These centre heads are supported on a bar, so arranged as to be held in line or at right angles to the planer motion. Both the clamp vise and centre heads are classed as extra tools, (Extra tools.) and not included in the price of the machine, inasmuch as where several shaping machines are used in one shop, it is not always deemed advisable to furnish each with a full set of extra tools. Inquiry is frequently made for shaping machines with long bed

and double planing head, to operate on connecting- rod ends and work of a like character. We make a solid base casting, upon which we bolt the beds of two shaping machines, so arranged as to insure their being at all times in line, and capable of being operated as distinct machines or in conjunction as one machine. We deem this preferable to one long bed with two heads on it, driven from one cone pulley. . **Double heads.**

This we term our DOUBLE SHAPING MACHINE.

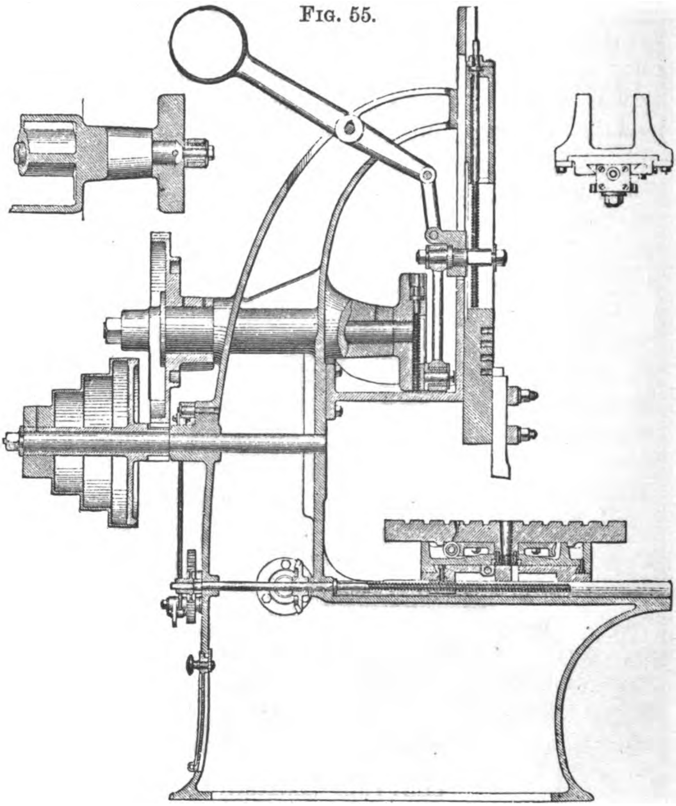
Fig. 54.



SLOTTING MACHINE.

With slotting bar counterbalanced so as to run without jarring; is driven by a variable crank, with quick return motion; bearing for slotting bar adjustable vertically, to suit the different heights of work; compound tables with circular plate and centering stud; feeds self-acting in all directions; over-head shaft, iron cone pulleys turned inside, so as to be perfectly balanced; ball and socket hangers, and wrought iron wrenches. Wrought iron work case hardened.

FIG. 55.



SLOTTING MACHINE.

To	admit	30	inches	diameter.	7½-inch	stroke.		
"	"	36	"	"	9	"	"	
"	"	42	"	"	10½	"	"	
"	"	48	"	"	12	"	"	
"	"	60	"	"	15	"	"	
"	"	72	"	"	18	"	"	

SLOTTING MACHINES.

THESE machines, as in the case of our shaping machines, are provided with the so-called "Whitworth motion" to the slotting bar, giving a slow movement under cut and a quick return motion. They are adjustable in length of stroke and in position of the slotting bar in height from the table upon which the work rests, and the bearing or slide in which the slotting bar works is also adjustable, to suit the different heights of work and to enable the bar to be guided as near to the work as possible, thus giving great steadiness to the motion. In some kinds of work this adjustable bearing may be set down near to the table, and thus give a firm backing to the tool during the whole of its stroke. The slotting bar is counterbalanced; this effectually prevents jar in running, the lost motion being all taken up by the counterweight in the direction of the force exerted in making the cut. The compound table is provided with a circular table, operated by wheel and tangent screw with self-operating feed. An important feature of this machine is the arrangement of its feed motion, which insures the feed always occurring at the top of the stroke and never during the cut. The great advantage of this will be manifest when it is remembered that should the feed occur at lower end of stroke the rigid tool will drag back with a pressure due the amount of feed. The working handles to operate feed by hand are on all these machines, even on the largest size, within easy reach of the workman, and in

Whitworth motion.

Adjustable bearing.

Slotting bar counter-balanced.

Table.

Feed.

Handles.

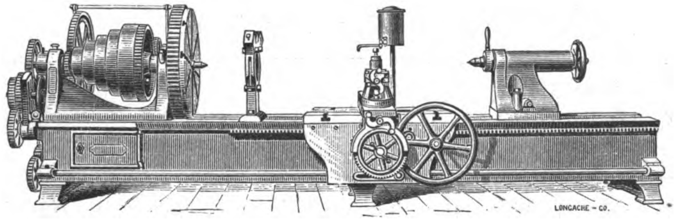
such a position as to enable him to readily see the point of the slotting tool as he adjusts the feed,—an advantage quickly appreciated when the machine is used to slot to scribed lines. Apart from the stability of the machine, and the great care taken in the construction, these machines possess advantages over any other style we have seen, doing more and better work with the same grade of workman. This advantage obtains mainly from the exceeding convenience of handling. There is scarcely any machine tool requiring more close watching on the part of the workman on the class of work it is required to do; it seldom takes long cuts, it generally being but a little while under power feed at a time, and then its amount of production, all other things being equal, depends upon the readiness with which the attendant workman can do his part of the movements in adjusting and re-adjusting the work in various positions and keeping the tool under cut as much of the time as possible.

Advantages.

For speed of counter-shaft of the various machines we give the following table:

Size of machine.	Diameter and Face of Fast and Loose Pulleys.	Revolutions per Minute.
30 inches	10 inches by 2¾ inches	260
36 "	12 " " 3⅛ "	226
42 "	14 " " 3½ "	204
48 "	16 " " 4 "	186
60 "	20 " " 4½ "	157
72 "	24 " " 7 "	130

Fig. 56.



SELF-ACTING SLIDE LATHES.

For 48 Inches Swing and Under,

With screw cutting and turning feeds so arranged as to be instantly changed from one to the other, when both are in gear with the spindle; turning feed adjustable to any speed between the fastest and the slowest; for lathes to swing 16 inches and under, the turning tool has a vertical adjustment on a single slide rest; for 20 inches and above, the slide rest is compound; and for 25 inches and above, this rest has a self-acting cross feed; quick hand traverse to bottom rest on all sizes; for 20 inches swing and under, the spindles are made of hardened cast steel, running in hardened cast steel bearings, and all other sizes up to 48 inches, inclusive, have steel spindles, running in best composition bearings. Beds flat on top, with improved hold down for poppet head, insuring the centre being in line with the axis of live spindle. Concentric hold fast to spindle of poppet head. Back stay.

Lathes over 48 Inches Swing,

With cast iron spindles, and the cone pulleys and back shaft drive through the face plate only, with fifteen changes of speed: self-acting screw feed, used for both screw cutting and turning, and self-acting cross-feed; bed with three flat surfaces for saddle, so arranged as to receive pressure of cut within the bed surface; rack movement for shifting poppet head.

Feed screw on all sizes supported the entire length. Beds of any required length. Over-head shaft with ball and socket hangers and iron cone pulleys turned inside, so as to be perfectly balanced; wrought iron wrenches. Wrought iron work case hardened.

LATHES, SELF-ACTING SLIDE.

Name of lathe: that is, diam. of piece will swing clear of bed.	Diam. will swing over rest.	Distance from centre to centre of girts.	No. of girts beyond live head.	Distance between centres.	Total length of bed.
12″	10″	10″	4	2′ 5¼″	4′ 4½″
16″	13″½	13″	4	3′ 2″	5′ 8⅝″
20″	17¼″	16¼″	4	4′ 0½″	7′ 1″
25″	21⅞″	20¼″	4	5′ 1″	9′ 0¼″
30″	26⅛″	24⅛″	4	6′ 0⅞″	10′ 9″
36″	31⅞″	29″	4	7′ 4½″	12′ 10⅝″
42″	37½″	33¾″	4	8′ 7½″	14′ 11″
48″	42⅝″	38½″	4	9′ 10½″	17′ 0¾″
60″	49″	28″	6	8′ 10¼″	17′ 2⅛″
72″	57½″	31⅛″	8	15′ ¼″	25′ ¾″

PROMINENT in the list of tools for the equipment of the workshop stands the lathe. It was the first machine tool; it is the most important. Upon it has been expended much thought, and about it much has been written. During the past few years the lathe has been greatly improved; its functions have been carefully studied, and its form changed to agree with the now better-known theory of its operation. Traditional shapes and devices have been discarded, and new ones are becoming familiar to the men who use it.

Requirements. It must be conceded that the requirements of a

good turning lathe are that it must turn a true circle, it must turn a true cylinder, and it must, when facing off, produce a true plane surface. The screw-cutting lathe must, in addition to these requirements, produce a sufficiently perfect thread. It is not only necessary that the lathe should fulfill these requirements when new, but it should continue to fulfill them year after year, with the least possible need of adjustment and repair. It has been said that good workmen can do good work with poor tools. Skill and ingenuity may indeed accomplish great results; but the problem of the day is not only how to secure more good workmen, but how to enable such workmen as are at our command to do good work, and how to enable the many really skillful mechanics to accomplish more and better work than heretofore; in other words, the attention of engineers is constantly directed to so perfect machine tools as to utilize unskilled labor.

Lathe must do good work with less skill.

The turning lathe, being the oldest of all machine tools, has been more hampered by traditional devices and shapes than more recently-contrived machines. Changes for the better have to be made, often in opposition to prejudices of the workingmen. This opposition has not, however, deterred us from steadily improving this machine, as new uses and new requirements seem to demand a change. Much more is required of the turning lathe now than was expected of it but a few years ago; more and better work must be done by it with less skillful workmen, and it must be adapted to the various kinds of work required of it in particular kinds of manufactures. Thus many lathes, adapted to special purposes, have been designed and designated by the names of the classes of work they are intended to accomplish.

Prejudice of workmen.

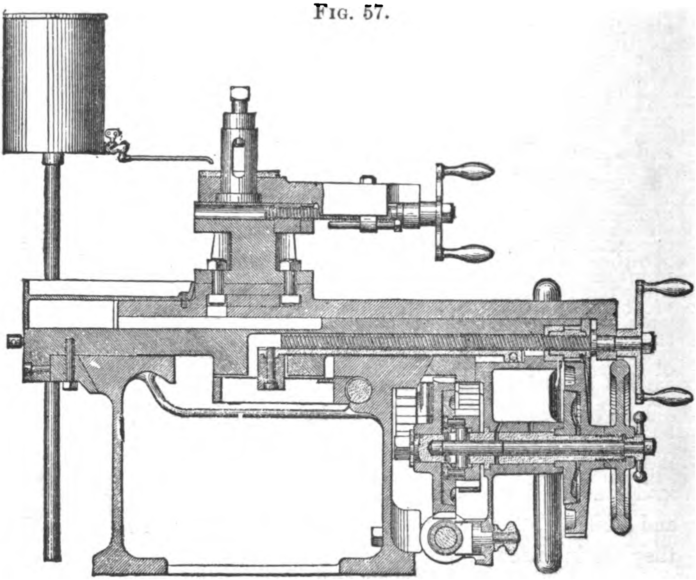
Lathes for special work.

10*

In reference to the bed or shear, we uniformly make what is known as the flat-top shear, and not the V shear. This latter has been the favorite in this country for many years; the flat-top shear is the rule, not the exception, in England. In view of the well-known fact that durability of machinery is largely dependent upon extended surface, where surfaces move or slide one on another, it is rather surprising that the flat-top shear should have met with so little favor in this country up to quite a recent period. Theoretically, it presents the largest wearing surface, and is the most easily made.

Flat-top shear.

FIG. 57.



The saddle of the slide rest, bearing over its whole under surface, may find a support up to the edges of the centre opening of the shear. Having less distance to span unsupported than on the V shear, the saddle can be made thinner and yet of sufficient strength, thus increasing the capacity of the lathe swing over the slide rest. On lathes with V guides there are usually four of these guides, the two outer ones serving as guides for the saddle, and the saddle must, of necessity, span the entire space unsupported from one V to the other; hence it must be thicker and heavier than if resting on a plane surface. The nominal capacity of any lathe is what it will swing over the shear. The actual capacity in relation to cylindrical work is what it will swing over the slide rest; hence the advantage of less thickness in the saddle, if of sufficient strength.

Saddle made thinner.

Nominal capacity of a lathe.

Those workmen who have not used lathes with flat-top shears are apt to think that the extended surface in contact with the shear may make it hard to move. If it be allowed to stick fast with gummy oil, this may be so; but with such care as any machine-tool should receive at the hand of the workmen, it is really easier to move. Friction being dependent upon weight, not surface, the flat-top shear, owing to the extended bearing surface, will permit the use of much lighter saddle, and the dust and dirt are no more apt to catch upon the flat shear surface than on the V shear, and are as effectually pushed off by the saddle. Lightness in the slide rest becomes of great moment on lathes of large capacity, and is worth considering in all lathes.

Friction depends on weight.

Makers of engine lathes, who still adhere to and recommend the V shear, build their lathes for turning

car axles with a flat-top shear. The axle lathe, but for the extended surface on the flat-top shear, would soon wear hollow at the place where most work is done. The advantages to be derived from the use of the flat-top on the axle lathe should recommend its adoption on other styles of lathes.

Facility of construction.

The flat-top shear can be readily planed true on its upper face, on its outer edges and on its inner edges. The outer edges guide the saddle, lost motions being taken up by shoes or gibs. The lathe heads are guided by the inner edges. The parallelism of all these edges can be readily insured. Convenience in moving requires that the poppet or back head, which

Guide for back head.

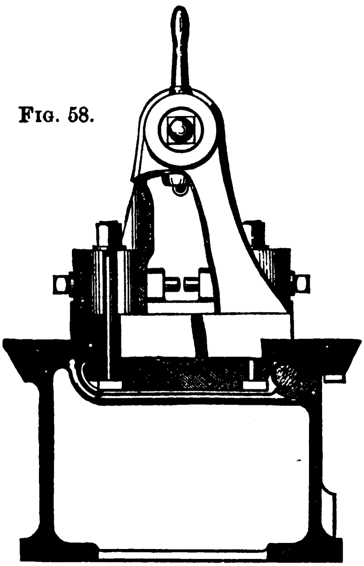


FIG. 58.

(with the flat-top shear) is guided by the inner edges of the shear top, should slide easily, and therefore should fit loosely. It is of the utmost importance that it shall always hold the same position as to line with the other parts of the lathe when clamped. This suggests the placing of a V on the under side of one of the inner edges, and thus, by means of the clamping shoe, draw the head always up to the same straight-edge.

We consider this combination of a clamping V on

the under side of the shear top with the flat surface above it as one of the most important modern improvements on the lathe.

The function to be performed by the lathe shears or bed is to maintain the driving head or live head spindle in line with the poppet head spindle, and to carry the cutting tool parallel with this centre line. It must do this under various conditions of strain. Screwing up the centre to hold the work, tends to bend the shear in one direction. The strain of the cut tends to bend it in another, in fact, in several directions.

Function of the shears.

Twisting of shear under cut.

It must be borne in mind that the lathe centres, being above the shear, and dependent entirely on the stiffness of the shear for their rigidity, are placed at some disadvantage in regard to leverage. A clear idea can be obtained of resultant strains if thought be directed to a lathe with a rigidly fixed live head and a very flexible shear. The work, being also rigid, will be driven around its axis by the rotation of the live head spindle, and will therefore tend to turn the slide rest, the shear and the poppet head around the axis of rotation, thus producing a severe torsional strain on the bed. Hence the bed must resist strain in all directions; the longer the bed the more elastic it would be in regard to torsion, an evil to be corrected only by the system adopted by us of introducing cross girts in all our lathe beds. These cross girts, from the peculiar construction of our lathes, extend near to the top of shear, and form inflexible ties between the two I beams, which represent the sides of the shear. The lead screw in screw-cutting lathes is placed within the bed, and, supported over its entire length by resting in a trough planed out to receive

Cross girts.

Lead screw in trough.

it, it is not subject to deflection; maintaining its right line will produce a truer thread, than if unsupported, except by the nut and end-bearings. By being placed under the shear top, it is entirely protected from falling chips and dirt.

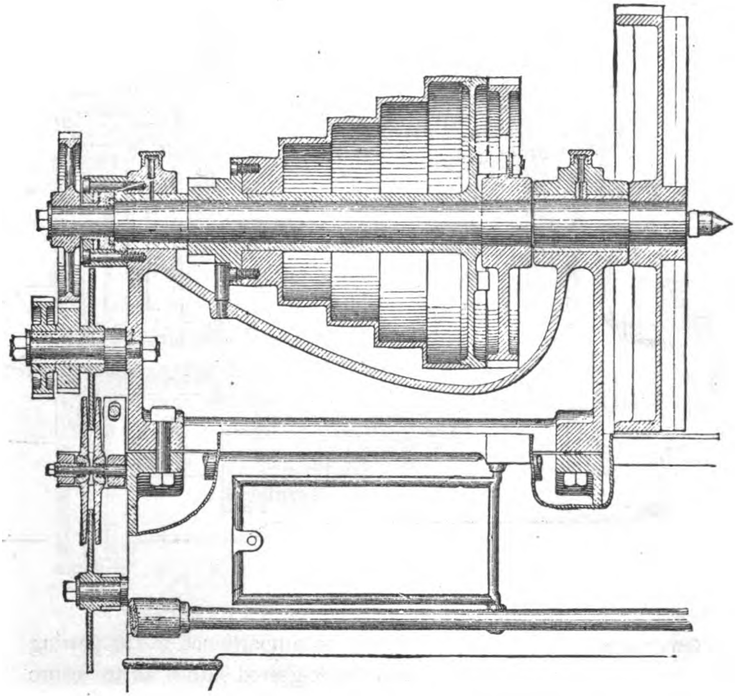
Spindle. Upon the perfection of workmanship on the spindle of the live head depends the possibility of turning a true circle; upon its freedom from end motions and the exact placement at right angles to it of the line of cross slide of the slide rest, depends the possibility of producing a true plane in facing.

The spindle must be round—truly round—as it will reproduce its own shape in the work being turned.

Spindle of hard steel. Theoretically, a hardened steel spindle, running in hardened steel bearings, the spindle and bearings being made true after having been hardened, presents the most reliable conditions of correctness and durability. Fortunately, the modern improvements in mehtods of working hardened steel furnish means of perfecting this important part of the turning lathe; but to adapt it to the possibility of economical construction, more important changes must be made in form.

No collars. The customary collars at each end of the journal are dispensed with, and the front journal of the spindle made truly cylindrical and supported over its entire length by a truly cylindrical bearing. **Back bearing.** The back bearing is conical, and one stationary ring or collar of hardened steel secured to the spindle back of the back bearing, is ground true, and is made to run between hardened steel plates without any lost motion whatever, and no liability to stick or jam. This form of back thrust does away entirely with the tail screw, presents a larger and durable wearing surface, and permits the spindle to be extended through

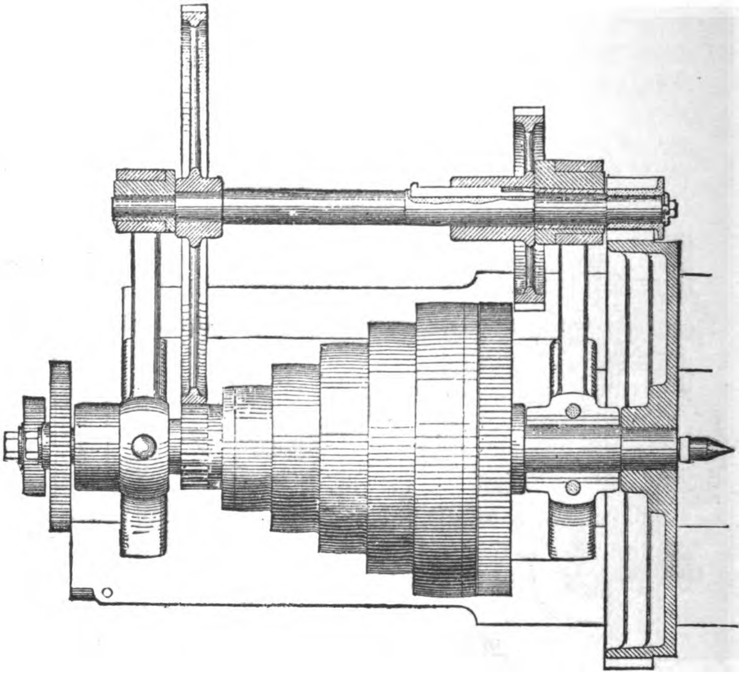
Fig. 59.



the back support, and thus receive change wheels of any size for screw cutting or feed. The form of the live head stock is such as to hold the front bearing in a rigid manner against lateral strains, and the back bearing against a strain of the spindle pressed endways.

Stiffness of head.

FIG. 60.



Cone pulleys. The cone pulleys are so proportioned to the gearing on back-geared and triple-geared lathes as to insure an exact ratio of change from the fastest to the slowest speed in each and every change,—that is, with five lifts to the cone in a triple-geared lathe, 15 speeds should be possible, each proportionately slower than the one next to it. The cone pulley on spindle is turned inside and out, so as to be perfectly balanced, and, in its inner sleeve, presents an extended bearing upon the spindle capable of proper lubrication.

15 speeds.

The spindle of lathes of 20 inches swing and under is of the best cast steel, and, being first roughed out, is hardened and then reduced to proper shape and size by suitable machinery. The taper hole for the live centre is finished true after the spindle is made true on the outside. The truth of this hole is just as important as the accuracy of the outside of the spindle. Upon its absolute concentricity with the outside of spindle depends the possibility of the centre point running true, no matter how replaced after it has been taken out.

Taper hole for centre.

Too much care cannot be taken with the manufacture of this important part of the machine. Hardened steel spindles have been made in this manner for lathes as large as 48 inches swing, the front journal of such a lathe being 5 inches in diameter; but the practical difficulties in the way of working with safety such large masses of hardened steel prevent its adoption for spindles over about three inches in diameter.

Face plates.

On all double-geared lathes we make the face plates to unscrew for convenience of changing to various sizes and the ready application of chucking devices. The overhanging end of the lathe spindle to receive the face plate has a portion of its length next to the shoulder, cylindrical without any screw thread. The screw on the end is short and fits loosely in the face plate; but a careful fit is made in the face plate of the part carried by the plane part of the spindle, and the shoulder against which the nut of the face plate abuts is made very true. This arrangement insures the face plates always running true, no matter how frequently they are changed nor how loosely the screw may fit, provided they are not bruised or injured in the fitting parts.

Durability of hard spindles.

Spindles made as described have been tested during many years' constant hard usage, and have been found to show no appreciable wear. Possible adjustment of all wearing parts should be provided, but such adjustment should not be at the convenience or whim of the workman using the machine, as is the case with the spindle collared at its journals and provided with a tail screw for the back thrust.

Fig. 61.

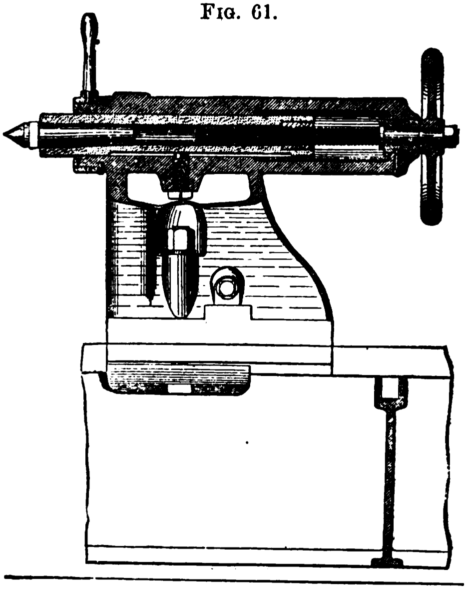
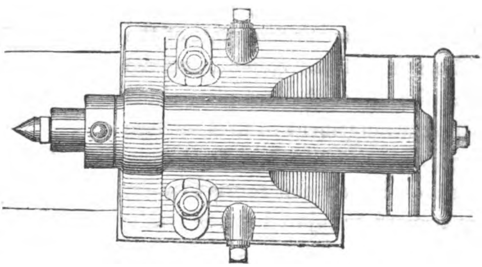


Fig. 62.



We have already mentioned the method of holding the poppet head so as to insure its alignment by means of the V on the under side of the flat-top shear.

Its spindle is carefully fitted, and is clamped at the extreme end of bearing, next to the work

by means of a split conical sleeve forced in by a screw, which takes up all lost motions or play and insures its central position. If lathes were not required to turn tapers as well as cylinders, there can be no doubt that the poppet head, made in one piece, resting on the shears over a sufficiently broad surface and capable of adjustment sideways only to the extent of practical alignment, would be the simplest and the best. In our own practice we prefer this system, and adapt to lathes requiring it a device which enables the turning tool to be guided by former bars, and thus to produce tapers or irregular shapes, such as the curves of handles, etc. This device, called technically "a former attachment," does much better conical or tapered work than with the centre set over out of line, for reasons obvious to all mechanics familiar with the use of the machine, and gives a greater range to its capacity. We may be pardoned for mentioning in this relation what we consider the readiest method of bringing the centre in line after the head has been set over, in adjusting the centres in the first place or in testing the correctness of a new lathe. A bar of round iron carefully centered, is turned up a short distance on one end. This turned end being placed next to the live head centre, a turning tool clamped in the slide rest is made to just touch the turned part. Taking out the bar the tool is then moved over to the poppet head spindle, and the bar reversed with its turned end next to poppet head centre, when, if the tool just touches the turned part as before, the lathe may be considered in adjustment.

Turning tapers.

Former attachment.

How to line centre.

In lathes in which the turning feed is independent of the screw cutting feed, we use our patent feed discs, which permit a gradation to suit the nature of the

Feed discs.

work between the extremes of speed. When (as is the case in large lathes) there is an automatic cross feed provided, the various feeds are so arranged as to be readily changed from one to the other. Having set in gear any one of the feeds, it can be stopped and started by one and the same motion for all the feeds.

Stopping and starting motions.

Such motions as screwing up the spindle of the poppet head, stopping and starting feeds, setting up the slide rests, etc., are motions of habit, and should, if possible, be uniform on all lathes. This is especially the case where two kinds of feed are operated by the same starting gear. No complication of motions should embarrass the workman. There should be no hesitation on the part of the workman as to which way he should move the starting gear in any case.

Slide rest.

The cross slide of the slide rest, in fact, all the slides of the rest, are so made as to entirely cover their sliding surface, and thus exclude all dirt. This is of the utmost importance, and too often neglected by makers of otherwise very good lathes.

Tool post.

For lathes up to 36 inches swing the very convenient single screw tool post can be used to advantage; but for larger lathes it is not possible to hold the tool in this manner alone, if the lathe is proportionally powerful. Four screws or standing belts with clamp plates serve a better purpose and admit of a greater range of tool positions.

Can do light work in a heavy lathe.

It is claimed by some that cheaper, lighter lathes will answer a good enough purpose. It has been clearly demonstrated that with a good lathe, made abundantly strong enough for the heaviest work, more and better work of a light character can be done than in lighter build of lathes. This is due, in the first place, to perfection of workmanship in the tool, and

secondly, to its freedom from vibration and absence of deleterious lost motion.

No end play in spindle.

A very marked saving of time is manifest in the use of these machines, from there being no adjustments required in the working parts by the workman. Work chucked in the face plate, or held between centres, is operated upon without any change in the back thrust of the live spindle. In reference to the table accompanying the specification, it will be seen that for each size the distance between centres and total length of bed corresponding is given for the shortest length of lathe bed made. In column headed "Distance from centre to centre of girts" is found the amount that the bed may be lengthened by the addition of similarly spaced cross girts. To understand this properly, it must be borne in mind that the shears or bed can be cast of any desired length, but the spacing of the cores which make the inside of shears makes it necessary to gauge the length not only by feet and inches, but by addition of girt lengths. Thus: an inquiry is made for a lathe to swing 25 inches over the shear and to turn 10 feet between the centres. Reference to the list shows that the shortest length of 25-inch lathe takes in 5 feet 1 inch; this is 4 feet 11 inches too short; distance from centre to centre of girts is $20\frac{1}{4}$ inches, 3 additional girts $20\frac{1}{4} \times 3 = 60\frac{3}{4}$ inches, $= 5$ feet $\frac{3}{4}$ inch, added to 5 feet 1 inch $= 10$ feet $1\frac{3}{4}$ inches, which will answer for the case, and is the nearest that it can be made to the required size; but should the lathe be required to take in 10 feet 6 inches, an additional girt will be needed, making 4 extra girts, and such a lathe will take in 11 feet 10 inches; this is the nearest to the size our patterns will admit of.

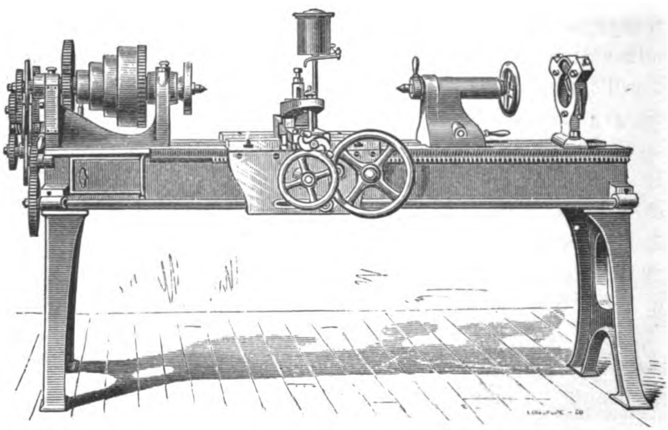
Estimating length to turn.

Spacing of the cross girts.

Example of length.

48-inch lathe. All our lathes, up to 48 inches swing inclusive, are made on one general principle, so far as form is concerned. There is a similarity in most essential parts, but a difference in detail.

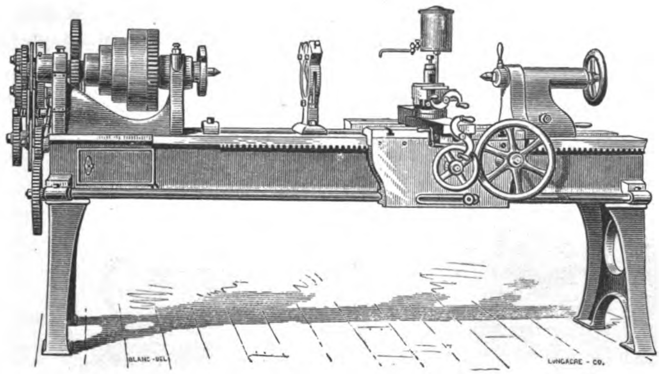
FIG. 63.



16-INCH LATHE.

16-inch lathe. OUR 12-inch and 16-inch lathes have a vertical adjustment to the point of the tool, by the use of a patent adjustable tool-holder. (See Fig. 63.) This is more needed in turning small diameters than large ones. The spindle is of hardened steel, running in hardened bearings. The poppet head is quickly clamped by a single handle.

FIG. 64.



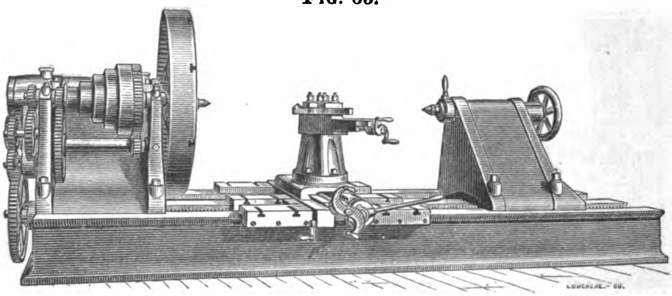
20-INCH LATHE.

OUR 20-inch lathe has a compound slide rest, but has no power cross feed. Its poppet head is clamped by a single handle, as on the 16-inch lathe, and its spindle is hardened steel. running in hardened bearings. **20-inch lathe.**

This size lathe, made with a sufficiently long shear or bed, has been found in our experience to be the best size for making lead screws, or other long screws. When arranged for screw cutting and turning, and fitted with a former turning attachment, it is the most useful lathe for general work of a size that will swing in it. It is in a 20-inch lathe that we make all our steel spindles for other lathes. We have lately increased the belt power of this machine by widening the face of the cone pulleys. We have patterns for extra large face plate when desired, and can also fit patent chucks of any desired kind to special face plates when so ordered. **Cutting lead screws.** **Fitting chuck.**

Over 20 and up to 48 inches, inclusive, there are automatic cross feed and longitudinal feed, so also in the still larger sizes; but up to 48 inches the feeds for turning are independent of the screw-cutting feed, while for sizes over 48 inches there is but one feed for screw cutting and turning.

FIG. 65.



We are enabled to produce a lathe for diameters over 48 inches in this manner at less cost, and answering in many respects a better purpose, than upon the plan of the smaller sizes. These large lathes are admirably adapted to doing very heavy work, such, for example, as turning rolls for rolling-mills, in which case the cuts required are very heavy, and at the same time they have a greater capacity over the slide rest than is attainable in lathes of ordinary construction.

3 flat surfaces on bed.

These large lathes have, in all cases, three flat bearing surfaces on the bed for the saddle to rest on.

Counter-shaft.

We make all the counter-shafts of our screw-cutting and turning lathes with one fast and two loose pulleys, so as to permit the use of open and crossed belts in cutting screws, and the driving pulleys on line should be arranged to run the lathe backwards at double the forward speed.

The proper speed is given in the following tables, which show the arrangement of counter-shaft pulleys both for screw-cutting and turning lathes, and for turning lathes only.

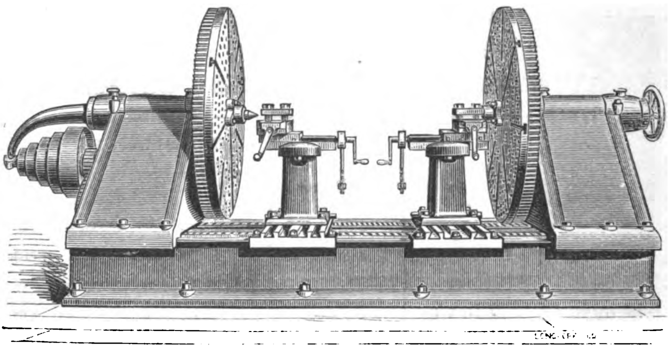
TURNING AND SCREW-CUTTING LATHES.

Size of Machine.	Speed under cut.	Speed Running Back.	Fast and Loose Pulleys.			
			Diameter.	Face.		
				Loose	Fast.	Loose.
12 inch.	200 Rev's.	360 Rev's.	6 inch.	4″	4″	4″
16 "	150 "	300 "	9 "	4″	4″	4″
20 "	112 "	224 "	10 "	5″	5″	5″
25 "	135 "	270 "	14 "	7″	7″	7″
30 "	110 "	220 "	16 "	7″	7″	7″
36 "	98 "	185 "	20 "	4″	7″	4″
48 "	90 "	180 "	26 "	6″	12″	6″
60 "	140 "	280 "	16 "	7″	7″	7″
72 "	122 "	244 "	20 "	8″	8″	8″

TURNING LATHE.

Size of Machine.	Speed under cut.	Fast and Loose Pulleys.		
		Diameter.	Face.	
			Fast.	Loose.
12 inch.	200 Rev's.	5″	2½″	2½″
16 "	150 "	8″	2½″	2½″
20 "	112 "	10″	3″	3″
25 "	135 "	12″	8½″	3½″
30 "	110 "	14″	4″	4″
36 "	98 "	18″	4″	4″
48 "	90 "	26″	6″	6″

Fig. 66.



PATENT WHEEL TURNING LATHE.

To swing 6 feet 8 inches diameter; extreme distance between face plates, 8 feet 6 inches; for boring or turning both wheels at once, with two gear head stocks, two large face plates, with external and internal wheels driven independently, so that the workman may be chucking on one and turning on the other at the same time; with two compound slide rests, self-acting feeds in all directions, over-head shaft, ball and socket hangers, and iron cone pulleys turned inside so as to be perfectly balanced, and a full set of wrought iron wrenches. Wrought iron work case hardened.

Same tool with one geared head stock and one slide rest; in other respects as above.

Same tool with one geared head stock and two slide rests; in other respects as above.

Pressure of cut within surface of bed.

THIS is believed to be the most efficient tool for turning driving wheels for locomotives that has been built. Its principle admits of unusual stability. The pressure of cut falls always within the bed surface, and its exceeding simplicity recommends it for the work it is designed to do. The feed is obtained from a rock shaft placed over-head, from

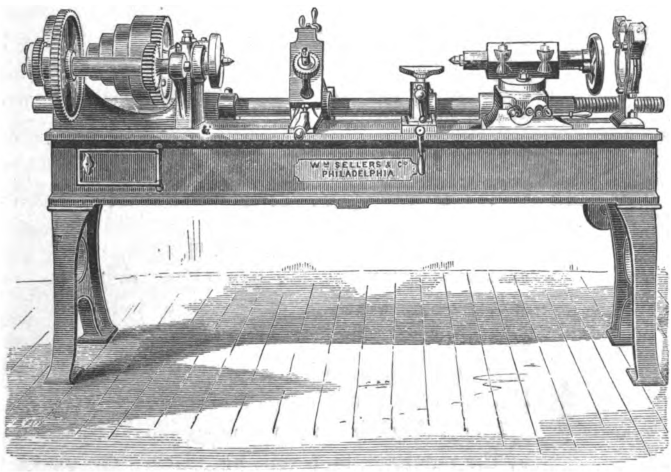
arms on which chains are carried to ratchet feeds on the compound slide rests. This enables the feeds to be operated to equal advantage in all directions by power, and to be entirely under the control of the workman. We recommend the machine with two driven face plates and two slide rests, but we make it when required, as is shown in specification, with one geared head stock only. The difference of cost, in our estimation, does not warrant the dispensing with the two face plates, the work being done so much more rapidly when both wheels are driven at once. By its use wheels may be taken from under an engine and the tires re-turned with but a few hours' detention of the engine in the shop. Fast and loose pulleys on the counter-shaft, 24 inches diameter, 7 inches face, 150 revolutions per minute.

Feed.

Two face plates.

Speed.

FIG. 67.



20-INCH CHASING LATHE.

20-INCH CHASING LATHE.

Arranged especially for brass work, live head back geared; hardened steel spindle running in hardened steel bearings; patent back thrust to spindle; iron cone pulleys turned inside so as to be perfectly balanced. Spindle for holding the chasing hobs so arranged as to accommodate two different pitches at the same time. Also to cut with single-pointed tool either single, double, triple, or quadruple threads. Slide rest for patent chasing arrangement carried by bar at back of lathe; counter-weight to chasing bar, pressing either to or from the face plate; poppet head with square spindle and detachable screw for quick motion, can be adjusted to any taper when used to carry turning tools, and is provided with slide rest movement; patent holdfast for poppet head; hand tool rest with convenient holdfast; steady rest; over-head shaft fitted with ball and socket hangers, and one fast and two loose pulleys, all 16 inches diameter, 5 inches face, which should run 168 revolutions per minute, with open and cross belts to run the lathe at uniform speed either way.

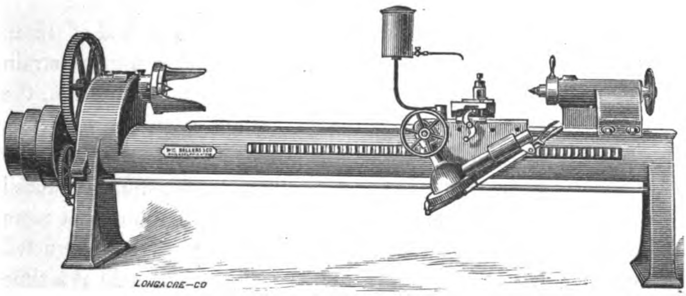
THIS is a special tool, made in the first place for our own use in our Injector shop, and there demonstrated to be a better tool for general brass work than any yet made. It cuts screws by means of a hob of the requisite pitch on the spindle back of the lathe spindle. The back or poppet head has all the movements of an ordinary slide rest, and is made to carry either boring tools or turning tools, and permits of the most economical working of chucked work. Lathes of this kind are not used for turning work between centres, but for operating upon work held and carried by the face plate; thus, upon the bodies of all kinds of globe valves and brass work generally.

Hob for cutting screws.

Turning chucked work.

To use it to advantage on any special work, a system of chuck plates adapted to hold the work (if a universal chuck is not applicable) should be arranged by the purchaser to permit his placing the pieces to be turned in the readiest way upon the face plate.

Fig. 68.



AXLE LATHE.

For turning car wheel axles; strongly geared for taking heavy cut; Clement's driver on face plate; spiral pinion; a rack feed with quick hand traverse to bottom rest; patent adjustable tool holder; automatic feed motion, which can be started instantly; rate of feed, 15 to the inch; can to drop water on cutting tool. All working parts fended from chips and water. Iron cone pulleys, turned inside, so as to be perfectly balanced; over-head shaft, with ball and socket hangers, and two sets of fast and loose pulleys, viz., 20 inches diameter, 4 inches face, which should run 120 revolutions per minute, and 12 inches diameter, 4 inches face, which should run 200 revolutions per minute. A full set of wrought iron wrenches. Wrought iron work case hardened.

THIS is one of our very important special tools, and in its design we had in view not only the greatest possible production, in work done in a given time, but also the greatest perfection possible in the work produced by not necessarily skilled workmen. In turning car axles there are two essential parts to be treated,—the "fit," that is, the part upon "Fit." which the wheel is forced, and which requires accuracy of size; the journal, which demands less accuracy Journal. of diameter, but requires to be truly cylindrical and

of smooth surface. It is customary to rough out the journal at one cut, taking out from $\frac{3}{4}$ of an inch to $\frac{7}{8}$ of an inch depth of metal, with a feed of 15 to the inch. This very heavy cut makes a great strain on the axle, and if, in addition to this strain, the mode of rotating the axle is not of such a nature as to insure its not being strained sideways at the face plate or driving end of the axle, the work produced will be out of round. It has been found that more and better work can be done with properly constructed lathes which turn but one end of the axle at a time than when the attempt is made to turn both ends at once, driving from the centre of the axle, as in the so-called double-headed axle lathes.

Strain of cut.

Turns one end at a time.

In turning the greatest possible number of axles in any given time, it is of importance that all the motions required to be made by the workman shall be done quickly; hence convenience of adjustment and handling becomes an essential feature of the machine. The shears or bed is made in the form of a continuous cylinder of requisite strength, with flat surfaces added to the cylinder for attachment of heads and bearing of slide rest. The live head or driving head is simple and powerful. The face plate is fitted with the so-called Clement's driver, which insures rotation of axle with no lateral strain on the centres. The back head has a very large, well-fitted spindle, with unusually large centre and a clamping arrangement, which insures the spindle being held central and at the point nearest to the work. On top of this head is a grease box to hold the lubricant for the centre at the handiest place for oiling the centre as the axle is being put into place. The slide rest, which is massive and strong, has an improved method of

Convenience.

Shape of shears.

Face plate.

Back head.

Slide rest

adjusting the point of the tool while under cut with care and precision. The feed is by a rack, operated upon by a spiral pinion after the manner of our driving motion in planing machines, with a clutch to stop and start, and, in addition, there is a powerful hand feed also. A water tank above the tool drips water on the work being turned, and proper guards turn aside the water and chips from the wearing surfaces. With these conveniences it is possible for one man to produce from 18 to 20 axles in ten hours. The value of the turned ends of car axles is assumed in this country to be fifty cents each,—*i. e.* one dollar per axle. It has been demonstrated that our lathe will enable an ordinary workman to turn at least two axles per day more than the same man can produce on the best machine heretofore made by any other maker. This represents a yearly increase of production equal to $600, representing the interest on $6000, at 10 per cent., a gain which will certainly warrant the payment of two or three hundred dollars over the price of similar machines that do less work.

Feed.

Production.

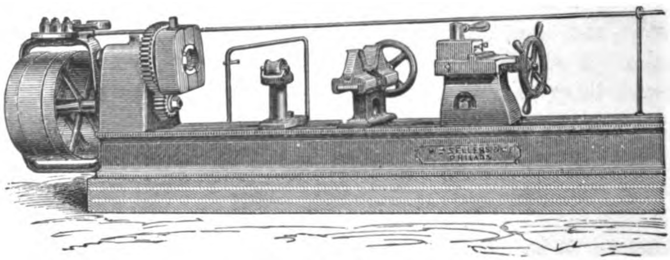
Value of work done.

In operating these lathes there are two speeds on the counter-shaft, the slow one for the roughing cut, and the fast one for the finishing cut.

The fast and loose pulley, 20 inches diameter, 4 inches face, should make 120 revolutions per minute, and those 12 inches diameter, 4 inches face, should make 200 revolutions per minute. These speeds may be obtained by driving from the same size pulley on the line.

Speeds.

Fig. 69.



AXLE CENTERING AND SIZING MACHINE.

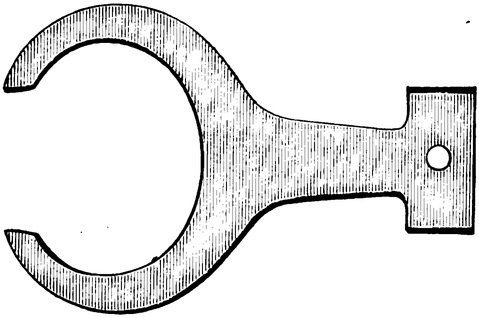
AS seen on page 135, we make a very convenient tool to be used in connection with axle lathes, to centre the rough axle, and after it has been turned to size in its journals and rough-turned in the "fit," to finish this part accurately, and to dress off the ends as well as to re-centre. This machine is pro-

Chuck. vided with a powerful chuck lined with brass to clamp the axle by its outer collar. It is arranged with fast and slow motions on the driving gear. The axle rests in an adjustable V-guide at its end farthest away from the driving head; a squaring-up tool finishes the end of the axle, and at the same time re-centres it. The

Reamer. "fit" part of axle is brought to size by a hollow reamer provided with adjustable cutting blades. The pulleys on machine are 20 inches diameter, and require 2¼-inch belts. There should be two pulleys on line shaft, each one 5 inches face, and of such diameter as will

Speed. cause the 20-inch pulleys to make 84 revolutions per minute for slow speed, and 264 for fastest speed.

FIG. 70.



CALLIPER GAUGES.

STANDARDS FOR INTERNAL AND EXTERNAL MEASUREMENTS.

¼ inch to 2 inches by *sixteenths*, 29 pieces.
2 inches to 3 inches by *eighths*, 8 pieces.
3 inches to 6 inches by *fourths*, 12 pieces.

Made of steel hardened on their ends, and afterwards ground to exact size.

THE importance of some uniform standard of measurement is manifest to all workers in metal. The standard plugs and rings made by Mr. Whitworth, of Manchester, England, have been accepted as correct. These standards are of too much value to be used as guides to size, in the workshop. In fact, rigid callipers, carefully fitted to these standards, are more convenient in use. We make such callipers, and adjust them to the original plugs and rings with great care. We recommend the purchase of two sets of these standards, as they cost very much less than a set of standard plugs and rings; one

Whitworth gauges.

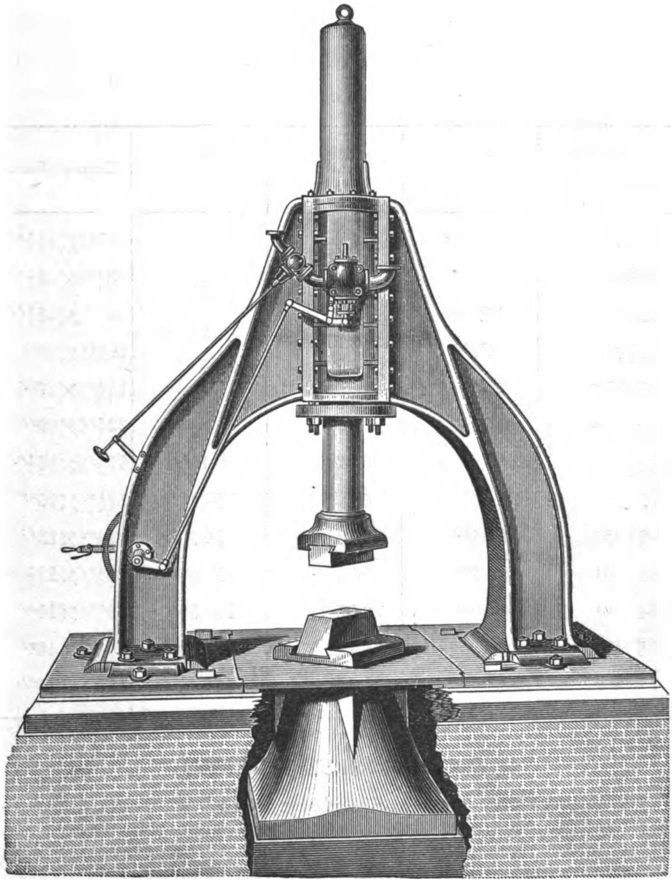
Two sets recommended.

set for use in the shop, the other to be kept in the tool-room and retained exclusively to adjust the working set. If one set only is ordered, it should not be used to calliper work in the shop, but be retained in store-room to set other callipers or gauges to. We find in our own practice, that uniformity of size is more readily maintained by use of these gauges, than is possible from the most carefully divided lineal scales.

SURFACE PLATES.

WE are also prepared to furnish surface plates, scraped to perfect planes, to be used as try-plates for obtaining true plane surfaces. No modern shop is complete without some of these plates, if only for special purposes. Thus, when slide valves are to be fitted to their seat, a surface plate of a suitable size should be used to true up the seat on the cylinder, and the valve either adjusted to the scraped seat or to the same surface plate.

FIG. 71.



DOUBLE UPRIGHT STEAM HAMMER.

STEAM HAMMERS.

SIZES.

Size or Weight of Hammer Ram.	Length of Stroke.	Height under Frame.	Width between Frames.	Hammer Face.
300 lb.	15½″	SINGLE UPRIGHT.	SINGLE UPRIGHT.	6¾″ × 4½″
650 "	18″			8½″ × 5½″
1000 "	20″			9″ × 5¾″
1500 "	23″			10¼″ × 6″
2000 "	27″			11¾″ × 7″
2500 "	31″			13½″ × 9″
1½ ton.	3′	5′ 9″	7′ 4″	16½″ × 9½″
2 "	3′ 4″	6′ 0¾″	7′ 10½″	17¾″ × 10″
2½ "	3′ 9″	6′ 6⅜″	8′ 9″	19½″ × 12″
3 "	4′ 2″	7′ 0⅛″	9′ 0¾″	21¼″ × 12½″
4 "	4′ 6″	7′ 5⅜″	10′ 6″	23″ × 14″
5 "	5′ 3″	8′ 4½″	12′ 3″	26½″ × 16″
7 "	6′	9′ 4″	14′	29½″ × 18″

GENERAL SPECIFICATION.

Piston rod or hammer bar of solid wrought iron, passing through both heads of cylinder; piston head forged solid with piston rod. Hammer head adjustable on lower end of bar; bar prevented from turning by upper cylinder head. Slide valve balanced.

Hammers of 2500 lbs. weight and under have one upright only, are double acting, taking steam above and below the piston, with self-acting valve gear and hand motion operated by the same lever: can be changed at will whilst in operation, thus affording complete control over the length, rapidity, and force of blow; also, enabling

the hammer to be used as a vise or squeezer. 1000 lbs. and under have anvil block passing through the base of upright. Hammers of 1500 lbs. and under are provided with a means of throttling the exhaust below the piston, so as to enable the blow to be diminished in intensity without materially decreasing the rapidity of motion. This attachment is of the utmost importance in finishing light work or tilting steel. All hammers over 2500 lbs. weight have double uprights and are hand-working only, taking steam above and below the piston, thereby increasing the force and rapidity of blows.

IN our introduction into this country of the "Morrison Steam Hammer" we were influenced by what seemed, in our judgment, the practical advantages of his system over all others then known. During the many years we have been making these machines, our attention has been constantly directed towards improving the mode of construction and increasing their durability and efficiency. The essential peculiarities of Mr. Morrison's system were in making the part which strikes the blow—that is, the hammer —of one long bar of wrought iron, having the piston welded to and forming part thereof, and guiding this bar by the top and bottom cylinder heads only, thus doing away with the usual side guides in the hammer frame, leaving the entire space below the cylinder free for the use of the workman in handling his work, whilst the hammer head and die are guided more efficiently than in any other system, and the frames are subjected to less strain.

Solid bar.

No side guides.

These hammers, as first constructed, had a uniform diameter of bar above and below the piston, with an enlargement at the lower end, in which enlarged part the dovetail for holding the dies was planed. The upper end of the bar—*i.e.* the part above the piston —was planed flat on one side, to keep the bar from turning. In practice, it was found that hammers

Flat on top end of bar.

made with this uniform diameter of bar and solid hammer head would in time give out immediately above the enlarged part of the bar at the lower end, because this is the place where the accumulated concussive force is intensified, resulting in some instances in fracture.

Liability to break.

Proceeding on the theoretical idea that in a bar of iron used as a battering ram, the mass of metal forming the ram should increase in sectional area towards the point of impact, we have been led to make the diameter of the piston rod or ram greater below the piston than above it, thus bringing the greatest mass of metal nearest the point of impact, and proportioning the parts so as to be better able to withstand the strain incident to each part.

Increase of bar below piston.

This change, while it made a very decided improvement in the durability of the bar, rendered possible a more important change,—viz., the attaching a loose hammer head, of the requisite size, to the lower cylindrical end of the hammer bar, by means of a circular taper key. Fastening the hammer head by means of this circular key has entirely done away with the possibility of breaking the bar by concussion. As now arranged, the force expends itself at the extreme end of the ram, in contact with the die face, and produces no other result than is attainable by hammering on this part,—*i.e.* on a surface great enough not to be burred up.

Loose hammer head.

Increased durability.

This system of loose head insures the durability of the hammer bar, it also permits the setting of the dovetail in any required position in regard to the anvil block, and admits of a ready repair of the part which holds the top die, if injured by careless driving of keys, etc. In reference to the keys used in holding dies, it will be found that each machine sent out from our

works has its die held by means of a crimped steel key, which is of uniform thickness (not made taper), and which holds the die with an elastic pressure. We recommend the use of this form of key in preference to any other, care being taken to re-bend when they become loose by use. Use of crimped key.

In our automatic hammers the motion to work the valve has been obtained from a diagonal groove in the upper end of the hammer bar. In early practice this diagonal groove was planed in the flat surface, which surface Mr. Morrison adopted as a means of preventing the bar from turning; but as this slot so made was found to cause a slight tendency to rotate the bar back and forth, it has been abandoned, and inclined grooves, diametrically opposite to each other, are made to work a brass yoke, whose line of vibration is through the central axis of the bar, thus entirely obviating the above objection, and very much increasing the extent of wearing surface, and permitting the guiding of the bar by brass keys in these opposite grooves. The simplicity of the valve motion in all our recent steam hammers recommends its use. Apart from this, we have modified the ports in the steam chest, so as to use a supplemental valve to throttle the exhaust below the piston, without impeding the free exhaust above the piston. This enables the hammer to strike quick, light blows for finishing; in other words, the hammer can go up as quickly, but in coming down its force may be gauged by the steam cushion upon which it descends, which steam, thus condensed in bulk, re-expands in the up stroke, to the manifest economy of steam used. To fully appreciate the importance of this improvement, it must be borne in mind that any attempt to gauge the intensity of the blow by throt-

Diagonal groove.

Inclined grooves.

Valve motion.

Choking exhaust below piston.

Light quick blows.

tling the ingress of steam to the cylinder, slows down its speed and renders its automatic blows irregular without proportionately decreasing their force, as in many cases the weight of the bar alone is too great for the character of work in progress. We cannot too strongly recommend this feature, which is placed upon all hammers of 1500 lbs. weight and under, such hammers being more often required to do both light and heavy work than the larger sizes.

In explanation of the efficiency of the valve motion as used by us, it must be borne in mind that the easy sliding balanced valve, obtaining its motion from the hammer bar, as above shown, is readily shifted upon the ports by the working lever and the length of stroke varied at will by the operator. In addition to this, if the working lever be moved by hand, in such a manner as to accord in time with the automatic stroke, the force of the blow is intensified to the extent of following the hammer bar down to the work with a full port open below for exhaust, and a full port for ingress of steam open above; in other words, the full force of the steam acts down through the entire stroke, adding to the weight of the bar the force of the steam, at whatever pressure it may be carried, acting over the whole piston area. It must be manifest to the most casual observer that the hammer bar as used in these hammers, in one solid mass of wrought iron, must be better adapted to the use of this steam force, to drive down, than are those hammers in which a cast iron "tup," or hammer head, sliding in side guides, is raised by means of a piston rod and piston attached to its upper end, and in which the down pressure of steam can only be exerted through the comparatively small diameter of piston rod.

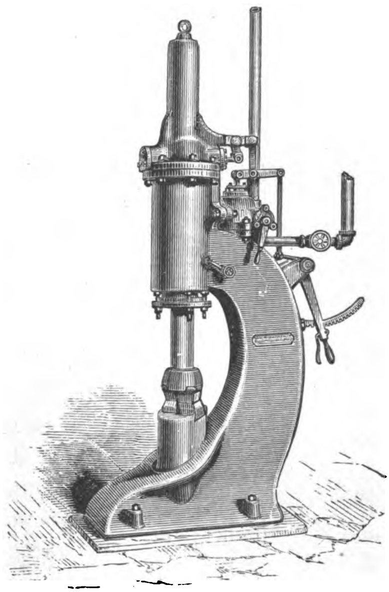
Balanced valve.

Hand lever.

Steam on top of piston.

A slow motion of the working lever will permit a corresponding slow raising of the hammer and its slow descent, with a squeezing force upon the work, so that it permits its advantageous use as a squeezer for bending and holding work between the dies, and in large hammers, when used for hammering puddled balls, it enables the loose ball to be pressed or squeezed into a compact mass before being hammered. In short, the valve motion with the one working lever enables the workman to have as perfect control of the rapidity, force, and character of the blow as is possible with a hammer held in his hand and controlled by his will. Hammers up to and including 2500 pounds weight of ram are made with one upright only; those of 1000 pounds and under are so made as to inclose in their base the top of the anvil block, which block rests on a separate foundation, and thus relieves the frame from shock.

FIG. 46.



The larger sizes of hammers, over 2500 pounds weight, are rated by tons, not by pounds, and are made with double uprights spread wide apart, affording ample room for easy manipulation on the part of the workman. The cylinder is securely bolted

Double uprights.

between these uprights, which, from their peculiar form, act as efficient braces to hold the cylinder firmly in position. The valve chest is placed on the back of cylinder, allowing the crane to swing up close to it, without any possibility of striking the valve gear. The working boy stands on the front of the machine, upon the floor level, not on a raised platform, thus enabling him to more certainly gauge the height of blow. In these double upright hammers the valve motion is not automatic, it having been found that hand-working hammers are more convenient for the use to which they are applied. The uprights of the hammers are bolted to extended foundation plates, these plates in turn resting on and being secured to the foundations, with an intervening layer of timber to give more elasticity. The anvil block rests on a separate foundation, with layers of wood under it for the same purpose. In reference to weight of anvil block, it is usual to make its weight, when used for hammering iron only, about five times the nominal weight of hammer; thus, for a two-ton hammer, the anvil block should not weigh less than ten tons; but, when used for hammering steel, it has been found advantageous to make the anvil block heavier,—say from seven to eight times the weight of the hammer. It is not essential that this extra weight be obtained in one solid block; it is as well to add weight by placing under the regular anvil block a wide-spreading under plate of the requisite additional weight.

Valve chest back of cylinder.

By hand only.

Foundation plates.

Anvil.

In speaking of the nominal weight of these hammers, it must be borne in mind that we rate our hammers by the actual weight of the hammer bar, not by the force of the blow. It is necessary to note this, inasmuch as some makers rate their hammers by some

Nominal weight.

assumed force of blow they are presumed to be capable of striking. Thus, our 1½ ton hammer has a hammer bar weighing 1½ tons. We do not indicate what its force of blow is,—such force being dependent upon many considerations, such as thickness of work being acted on, softness of material, and pressure of steam. We emphasize this, because this difference in mode of rating leads to wrong conclusions on the part of inquirers, who may think the price of our 1½ ton hammer high, as compared to the price of some other makers' 1½ ton hammer, which, in point of fact, may be a five-hundred pound hammer, striking, it is assumed, a 1½ ton blow.

In confirmation of the merits claimed for our method of constructing steam hammers, we annex copies of two letters received on the subject.

BLACK DIAMOND STEEL WORKS, PARK, BROTHER & Co.,
PITTSBURGH, May 25, 1871.

MESSRS. WILLIAM SELLERS & Co., Philadelphia:

GENTLEMEN,—We have in use at our works *two* of your *Steam Hammers.* Both of them are of your *fifty-five hundred-weight* size; but, owing to the weight of dies we are using, we call them "Our *Three-Ton Hammers.*"

The first of these we bought from you January 16, 1863. Soon after its receipt we put it to place, and ever since then it has been almost constantly in use—a part of the time on double turn—in forging heavy cast steel shafts and shapes.

The second Hammer was delivered to us October 31, 1865. This one has been in constant use in hammering our own make of iron into the shape of blooms.

We may say that, with the exception of some trifling repairs, these Hammers have not in any way given out, and are to-day about as good as new.

Your Steam Hammers, owing to their plan of construction, are admirably adapted to withstand the straining shocks to which all steam hammers are subjected.

The plan of construction of your *frames*, and the method adopted for fastening the *cylinder* thereto, cannot, in our opinion, be improved.

By abandoning the old plan—which is, we think, in use on all other makes of Steam Hammers—of working the head in the frame, and instead thereof working it as one piece with the rod, in and through the cylinder, you relieve your frames from the constant straining shocks they would otherwise be subjected to.

We know of no other make of Steam Hammers now in use equal to yours, and take pleasure in testifying to their superiority.

Respectfully yours,

PARK, BROTHER & CO.

THE BESSEMER STEEL WORKS,
TROY, N. Y., March 20, 1871.

MESSRS. WM. SELLERS & CO.:

GENTLEMEN,—In reply to your inquiry regarding our experience with your *Seven Ton-Hammer*, I take pleasure in making the following statement:

We have been running the Hammer almost constantly for about eighteen months, day and night, on steel. We produce thirty-five to forty tons of seven and a quarter inch blooms, from twelve-inch ingots, per twenty-four hours. Each ingot makes two blooms at one heat. The last bloom is, therefore, finished pretty cold, which brings very severe work on the Hammer.

Aside from the usual wear and tear, the Hammer has not broken nor cracked, nor shown any signs of distress.

My experience in working steel with heavy Hammers, in which the hammer head works in the frames, is that the frames are violently shocked and often broken by the *direct* lateral blows and strains of the head.

In your form, however, the lateral strains of the head are distributed over the whole arch of the frame, and are reduced in violence by the elasticity of the frame. The shape and proportions of the parts also appear to contribute to the distribution of strains, and to their *elastic* rather than to their direct and rigid resistance.

Yours truly,

A. L. HOLLEY,
Manager.

One of the hammers spoken of by Messrs. Park, Brother & Co., was the first hammer made by us. The one alluded to by Mr. Holley was the second one. Both are at this time (1876) in excellent order.

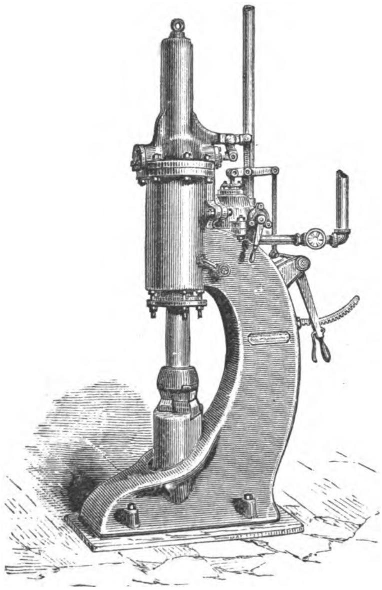
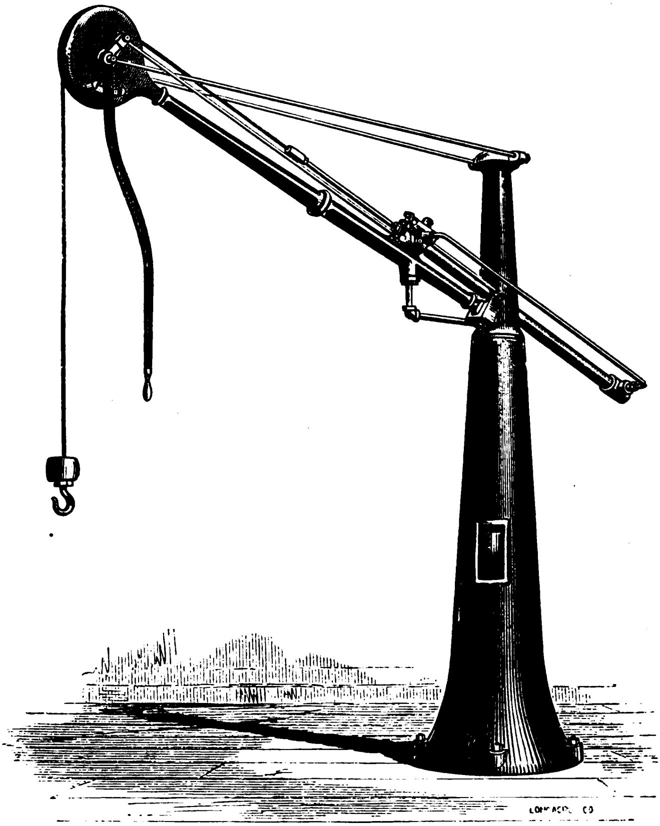


FIG 72.



HYDRAULIC MOULDING CRANE.

HYDRAULIC MACHINES.

Hydraulic pumping engines—Hydraulic accumulators for high and low pressures—Platform hoists, operated by water—Hydraulic moulding cranes for car wheels.—Also large water cranes for foundry use, arranged with very superior valves, and designed with especial view to durability and convenience; as well as hydraulic punching, riveting, and forging machines.

HAVING been engaged for many years in the manufacture of hydraulic machines, we have accumulated a large assortment of patterns of the various useful appliances of this very convenient mode of transmitting power and of using it in machines. We are prepared to furnish all that may be required for the introduction of hydraulic motors and machine tools into warehouses or workshops.

Transmitting power by water.

The very great convenience of the hydraulic system of working hoisting machines has caused its introduction into some of our largest works, and the improvements introduced recently have tended to materially decrease the first cost of the plant needed. This first cost, which may seem great when a single machine or hoist is to be operated, becomes trifling when the use of the power is extended to a wider range of machines. Thus, in any event a pumping engine and accumulator are required; but when these two machines are in place a very considerable number of machines or hoists may be operated from the same source of power with less cost for each machine, and very much less cost of conducting the power to it, than by any other known method. In this country the use of this power has been mainly confined to hoisting machines; but we have recently extended its use to all purposes of shearing, punching, and riveting machines, as also to forging presses and like purposes. We give on page 150 a cut of a very convenient crane for moulding pur-

Pump and accumulator.

Use in this country.

Water lifts for Pa. Railroad.

poses,—one of the series of machines designed by us for the use of the Pennsylvania Railroad Company in their wheel foundry at Altoona. In this machine the weight is raised and the empty hook lowered by power, with very little loss of water, so that the usual heavy ball at hook is not required, facilitating its use. The hand lever is near to the work, thus dispensing with an assistant to move the valve.

Ladle-tilting machine.

We have also arranged convenient ladle-tilting machinery for car-wheel foundry, and automatic cranes for placing the red-hot car wheels in the annealing pits. Some of the machinery of this description made by us has been in operation for more than fifteen years, without any notable need of repair. We have also extended its use to other machines for special purposes, clearly demonstrating the advantage and economy of the mode of operation.

Use of water cranes in the Bessemer mills.

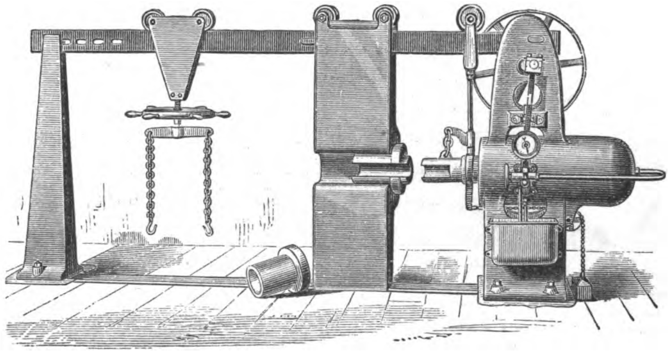
The universal employment of the hydraulic system in the operations incident to the Bessemer process has rendered many persons familiar with its use; but while the direct-acting crane commonly used in handling the ladles and ingot moulds in the Bessemer mills seems simple and convenient, it is wholly inadmissible with the greater loads and higher lifts needed in foundries. We have therefore adopted the system of drums and chains common to all foundry cranes, with the addition of convenient and durable water engines to impart the necessary rotary motion. They are so arranged as to materially economize the power over any plan heretofore brought to our notice, using water only in hoisting, not in lowering weights.

Foundry cranes.

Breaking machines.

We have patterns for breaking machines for casting, one having a lift of forty feet, weight of drop one ton, and a smaller one of ten feet lift and one ton drop.

FIG. 73.



HYDROSTATIC WHEEL PRESS.

Of capacity for putting two 6-feet driving wheels upon the axle at the same time; maximum power 150 tons. Cylinder lined with copper in an improved manner. Double acting brass pump arranged with pressure gauge and stop valve, and improved safety valve to prevent overloading. Chain slings and elevating screws for wheels and axles traveling on top rail of press. The resistance beam or post is suspended from wheels on top rail and movable to any position, thus acting equally well for pulling off and pushing on. Wrought iron work case hardened. Over-head shaft, with ball and socket hangers and fast and loose pulleys 36 inches diameter, 7 inches face, which should make 100 revolutions per minute.

Same machine of capacity for 36-inch wheels.

THESE machines, both the one for driving wheels, which takes in a 72-inch wheel, and the one for car wheels, which takes in 36-inch wheels, have a power of 150 tons. This power is not expected to be used to its full extent in pushing on wheels, but in pulling off those that have become rusted fast. In practice, it has been found that

Force required for car-wheel.

car axles made cylindrical (not conical) in the "fit," if made .007 inches larger than the hole in the wheel, require 30 tons to force on, and will never come loose in use. The value of the hydrostatic wheel press over any form of screw press is in the possibility of always noting the pressing force used. On some of the screw presses made it has been found necessary to adapt a hydrostatic cylinder and pressure gauge to resist the force of the screw, and thus indicate the pressure used. This led to the use of hydrostatic forcing machines exclusively, and the present machine is the result of many years' experience with this way of forcing on wheels, which experience indicated a rather short durability to the early machines, not lined with copper.

Iron cylinder not lined will break.

Those which we make are provided with copper-lined cylinders made without any break in the continuity of the lining, insuring durability. This method of making the cylinders is of great importance. The safety valve, which is inaccessible to the workman, will not permit a greater pressure than 5000 pounds to the square inch being obtained, and its spring is at all times relaxed except during the time of the press being in action, thus giving it ample time for rest and insuring its constant accuracy. The pump is of the best bronze, and is double acting. Fluid used is oil, and when the pump wheel runs 100 revolutions per minute the motion of the ram is seemingly constant. This is important, as with single acting pumps the wheel goes on with jerks. Fast and loose pulleys on the counter-shaft are 36 inches diameter for 7 inches belt, and should make 100 revolutions per minute.

Method of lining.

Safety valve.

Use oil.

Speed.

This machine stands at right angles to the line of shaft, but if the arrangement of the shop require its being placed parallel with the line, the power may be conveniently carried to it over a set of mule pulleys. **Position in shop.**

CUPOLAS FOR FOUNDRY PURPOSES.

With cast iron foundation plate supporting the columns which carry the cast iron base plates and doors for discharging waste contents, after heat; wrought iron case, wind chambers and valve, charging door and elbow to chimney so arranged as to deposit all the cinder at base of chimney. The whole fitted complete, with fire brick ready for lining the curved portion immediately above boshes.
Diameter of boshes: 24, 30, 36, and 42 inches.

A VERY excellent form of cupola, simple in construction and giving a good result in melting. The interior is of a shape to hold the lining with certainty, and to permit the placing of the tuyeres in any required position in the circle and of any number.

MOULDING CRANE.

With cast iron bed plate 9 feet 3 inches square, mounted on four wheels 48 inches in diameter; the gauge of track upon which it is to run being 9 feet 10 inches. Radius of jib swing, 11 feet 7 inches; distance from top of rail on floor to sheave at end of jib, 10 feet; hoisting machinery so arranged as to be self-sustaining, thus avoiding all danger of running down; platform for operator attached to centre post, from which position the load can be hoisted and the carriage moved upon the track. The whole complete with wire rope, and ball hook.

A VERY convenient crane for use in foundry for moulding car wheels, or similar work; will answer for weights of 1500 pounds. The wheels upon which it is carried, being 48 inches diameter, admit of its passing over flasks 22 inches high, above the rail.

CRANES FOR FOUNDRY PURPOSES.

With cast iron base and top plates; double set of gearing upon the base plate, so as not to be affected by the straining or shrinking of the timbers; top sheave frame iron, arranged to move the whole length of jib by means of a chain wheel near crank shaft; sheaves bushed with steel and revolving upon steel pins; ball and socket hook; the whole complete with all necessary chain, wire rope, bolts for timber work, and rails for top sheave frame.

5, 10, 25, and 50 ton crane.

AN important feature in these cranes is the arrangement of the jib and over-head carriage. Instead of making the jib horizontal, and carrying the hoisting chain from extreme end of jib over the sheaves, and thence back, over a sheave near the post, to the drum, we carry the chain from drum direct, diagonally to the carriage, and make the end fast to the lower block; then, with three upper and two lower sheaves, we hang the load on five strands of chain, instead of on four, as is usual, and thus work with much less friction. We drop the jib towards its end, so as practically to make the load more level in running it out and in. This enables one man to run the carriage and load, either out or in, with ease and dispatch.

Load on five strands of chain.

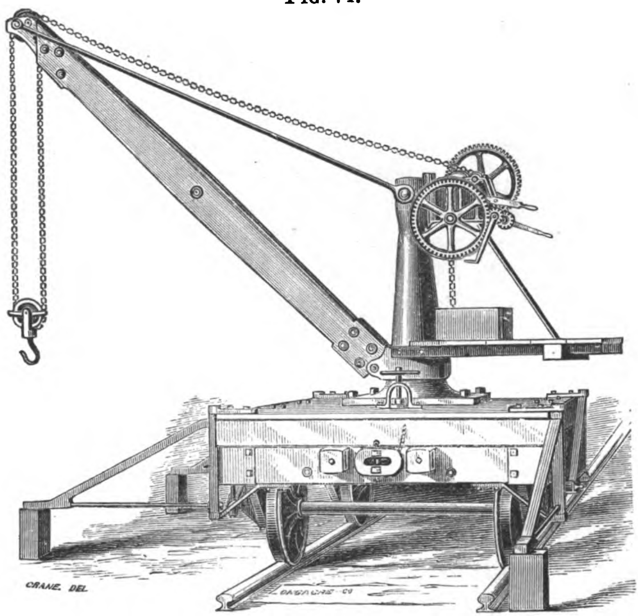
Two powers to machine.

There are two powers to the machine, and a means of shifting quickly from the one to the other, or to lock. We have patterns suited to 16 feet, to 25 feet, and also to 31 feet, height of room. The latter patterns are the most recent, and have several important features. They are capable of winding up a large amount of chain, so as to work in a room 31 feet high without having to override the chain on the drum. We have also adapted a patent brake to these large cranes, which enables the load to be held in any position, and lowered by friction, without danger to the workman.

Chain on drum.

Patent brake.

FIG. 74.



5-TON WRECKING CRANE.

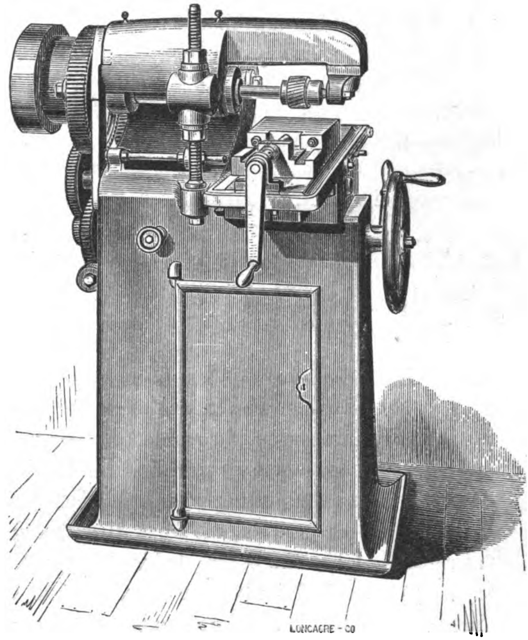
With cast iron post mounted on railway car of any required gauge of track. Gearing for fast and slow motion. Strap brake on large gear-wheel. Chain controlled by sprocket and guide wheel; not winding on a drum. Car with swinging wrought iron gates arranged to spread the base while the crane is in use.

THIS crane was designed in the first place for use on South American railroads, the crane to accompany goods cars and to be used in loading and unloading freight at way stations.

The chain passing over sprocket wheels is coiled in a box on the platform. This arrangement permits **Long chain.** the use of a very much longer chain than is admissible when wound on a drum in the ordinary manner, and diminishes the size, parts, and amount of machinery **Gates.** required in the hoisting gear. The swinging gates serve to spread the base of the car in any required direction when the crane is in use. These gates lock to the side of the car when not in use. Car is hung on springs; but blocking pieces are provided to wedge up the springs when hoisting.

We are also prepared to make cranes like the above for heavier weights, up to, say ten tons, but think a long car with two five-ton cranes on it preferable for some kinds of work. The cars can, in building, be adapted to any gauge of track.

FIG. 75.



MILLING MACHINE.

With 4 inches vertical and $4\frac{1}{2}$ inches longitudinal adjustment; with 14 inches transverse feed movement, the latter adjustable to every speed between the fastest and slowest; the vertical and transverse adjustment by double screw to take up any play; adjustable stop motion, clamp vise, over-head shaft, pulleys, ball and socket hangers. and wrought iron wrenches complete. Wrought iron work case hardened.

MILLING MACHINE.

THIS milling machine is very rigid, and capable of taking heavy cuts; very useful on gun work; in machine shop, can be used to advantage in fluting or grooving taps and reamers, etc., as also in keyseating short shafts.

GRINDSTONE BOXES.

With shaft and ball and socket bearings complete; the whole fitted to run upon wheels. Pulleys and grindstones extra.

To swing 42-inch stone 6-inch face.

" " 48 " " 7½ " "

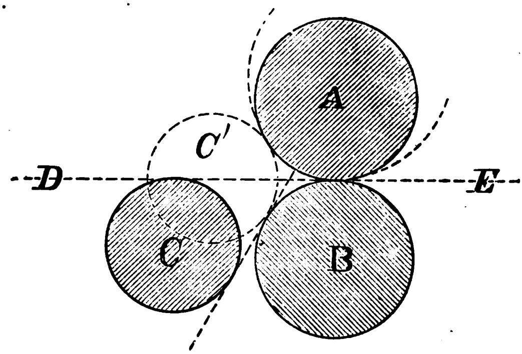
THESE boxes are of cast iron, in one piece, resting on three wheels, one of which is made to turn in a socket, for ease of moving the box to place. This arrangement permits the box to be run under a crane for putting stones in place, and when placed in proper position, the front wheel being turned at right angles to the others, holds the box stationary against the pull of the belt, at the same time, by moving the box, permitting the same belt to be used, without cutting, for large and small driving pulleys as the stone wears down and requires speeding up. When required to furnish pulleys, we select such sizes as will in use keep the stone up to speed as it wears.

BENDING ROLLS.

WE have recently made some important changes in the method of driving rolls for bending sheet and plate iron for boiler- or shipmakers' use. Before describing the tools, we would call attention to the principle involved in machines for bending plates of metal. The primitive bending machine still in general use consists of two rolls laid side by side and a third roll placed over these two, the top roll being adjustable vertically and being immediately over the hollow between the two lower rolls. In hand-power bending machines set up on this plan the levers to turn the rolls are usually attached to one end of one of the bottom rolls and the opposite end of the top roll. This plan is not admissible when rolls set up in pyramidal form are driven by power. Then it becomes necessary to gear the two bottom rolls, and frequently they are united by small pinions at one end. In such a case one bottom roll is driven, and that roll drives the other one through the pinions. The strain on the pinions coupling these rolls together is very great. The system is objectionable on this account and as involving much useless friction. We make hand-power bending rolls with the rolls set in pyramidal form, but never apply gearing and power to rolls so placed.

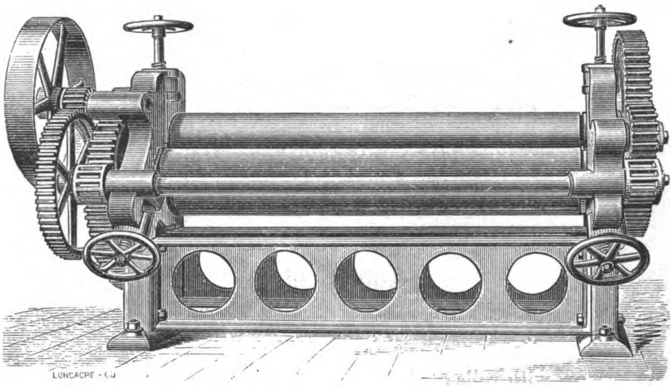
We are clearly of the opinion that the proper way to set bending rolls is to arrange two pinching rolls, one directly over the other, and both driven; then to place the bending roll to one side of the lower roll, with the housings so made as to guide the bending roll diagonally past the lower roll towards the upper one, as is shown in Fig. 76, page 162, in which the top roll A is placed directly over the bottom roll B. C is the bending roll adjustable towards A in the direction of the diagonal dotted line. When roller C is down far enough to have its top level with the top of roller

FIG. 76.



B, then a plate, D E, can be passed between rolls A and B without being curved; but when C is raised towards the position indicated by dotted circle C', then the plate will be curved. We make several sizes and kinds of bending machines embodying the principle as shown above. In some we put bending rolls on both sides of roll B, thus making the set to consist of four rolls. Our most recent improvement will be found illustrated and described on page 165 as our 10-foot power bending rolls.

Fig. 77.



POWER BENDING ROLLS.

Arranged with two pinching rolls, set one directly over the other, the bending roll movable at an angle to the pinching rolls. Pinching rolls geared at opposite ends, so that they are always correctly in gear while driving. The top pinching roll removable through housings at one end, so as to permit the bending up of flues. Over-head shaft with ball and socket hangers and three pulleys, 24 inches diameter, 5 inches face; for reversing by open and cross belts, which pulleys should make 180 revolutions per minute, requiring on main line a driving pulley 15 inches face.

ROLLS arranged as above present the advantage of being able to squeeze the plate between the two pinching rolls and bend nearer to the edge of sheet than can be done with three rolls set in the usual manner, *i.e.* two on a horizontal plane and one over the space between these rolls.

Bend near to edge.

We are prepared to make Power Bending Rolls for

For ship work. ship work, with four rolls in the system adjustable by power in height; these rolls are massive and can be used for bending plates 1 inch thick and 14 feet wide; will bend cylindrical or in-wind, while the sheet is passing straight (not diagonally) through the machine. These rolls can also be used for straightening plates in a much more thorough manner than can be done with hammers: they are intended for ship work. All the rolls have centre supports. **For large boiler plates.** We also have designs of a similar set of 4 rolls for boiler work, to take in plates 11 feet wide, having all the advantages of the above.

BENDING ROLLS.

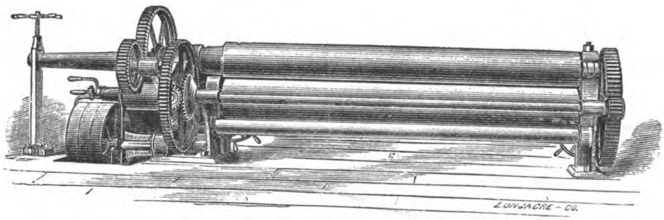
Made of best gun iron, for boiler plate; with strong iron frame, self-supporting top, and side rolls adjustable, to set on floor without foundations, with rolls 5 inches in diameter, 4 feet 6 inches long.

Same machine with all the rolls adjustable, housings and boxes complete, fitted to bolt on foundations.

Rolls 8 inches diameter, 6 feet 1 inch long.
" 9 " " 6 " 1 " "
" 9 " " 8 " 1 " "

THE first machine described in the above specification is intended for tank work, bending iron of not over $\frac{3}{16}$ inch thick; is admirably adapted for tank work, and can be used to advantage in coppersmith shop for rolling up pipes. The larger rolls are of the usual hand-working kind, and require pits at each end of the rolls for the lever arms to work in. The housings are independent, and must be secured to foundation.

FIG. 78.



10–FOOT POWER BENDING ROLLS.

Arranged with two pinching rolls, set one directly over the other, the bending roll movable at an angle to the pinching rolls.

Pinching rolls geared at opposite ends, the power being transmitted through a set of equalizing wheels, so as to rotate the rolls in proper relation to each other, and thus avoid any calendering motion on curved plates. The top roll made to tilt up at one end for the ready removal of flues, or sheets rolled into a full circle.

Arranged with patent belt shifting gear the same as on our planers and hoisting machines. Pulleys, 30 inches diameter, 4½ inches face; pulley on line to drive the machine must be 13 inches face, turned straight, and of such diameter as will give a speed of 178 revolutions to a 30-inch pulley.

AFTER much experience with machines for bending plate we designed this tool, and have introduced in it the improvements alluded to on page 161. It will be observed that the shaft which conveys the motion from one roll to the other is arranged with a set of equalizing gear wheels. The bevel pinions equalize the strain upon both rolls. When a plate of iron, ¾ inch thick, is curved into a cylinder, say 4 feet in diameter, it will be found that the

Equalize motion.

difference between the outside and inside circle of the sheet will cause a motion of the equalizing pinions of about ⅓ of their circumference. Rolls geared in this manner require less power to drive them than would be needed to drive rigidly geared rolls of the same size and length. This machine can be used to straighten sheets as well as bend them.

Straightening sheets.

The above arrangement of rolls is shown below in section.

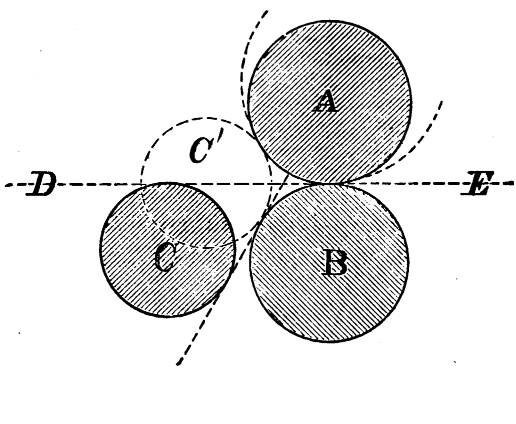
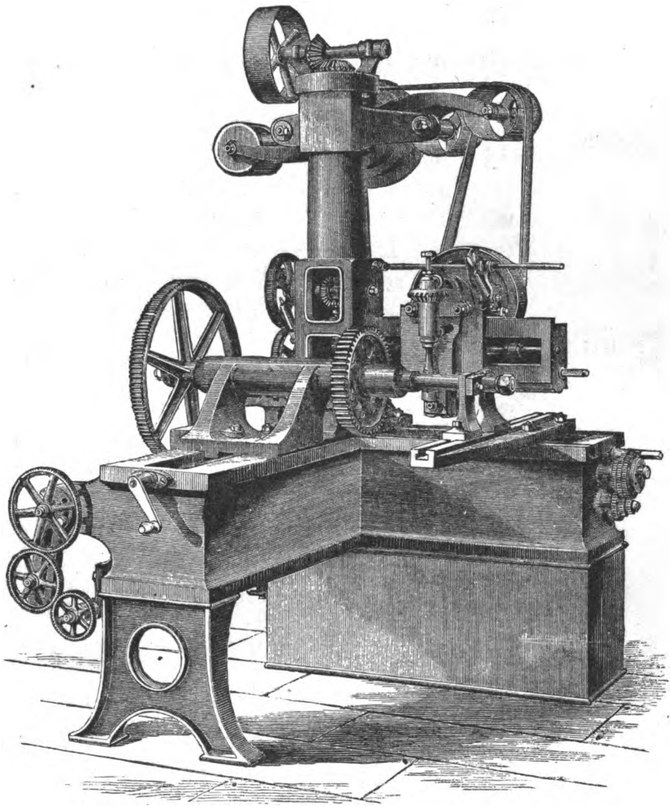


FIG. 79.



GEAR CUTTING AND WHEEL DIVIDING MACHINE.

Automatic in all its motions; arranged to cut bevel and spur wheels to 4 feet 6 inches diameter and 9 inches face. Division made by wheel and tangent screw carefully constructed. One full set of change wheels to effect division of wheels from 10 up to 360 teeth. Feeds self-acting and variable.

GEAR CUTTING AND WHEEL DIVIDING MACHINE.

Capacity.

THIS machine is arranged for cutting both spur and bevel wheels, has a capacity up to 54 inches diameter of wheel, 12 inches face, and will cut a number of small spur wheels of same size at one time. It is entirely automatic, performing all its work after adjustment, without attention of workman, to the completion of the wheel being cut or divided.

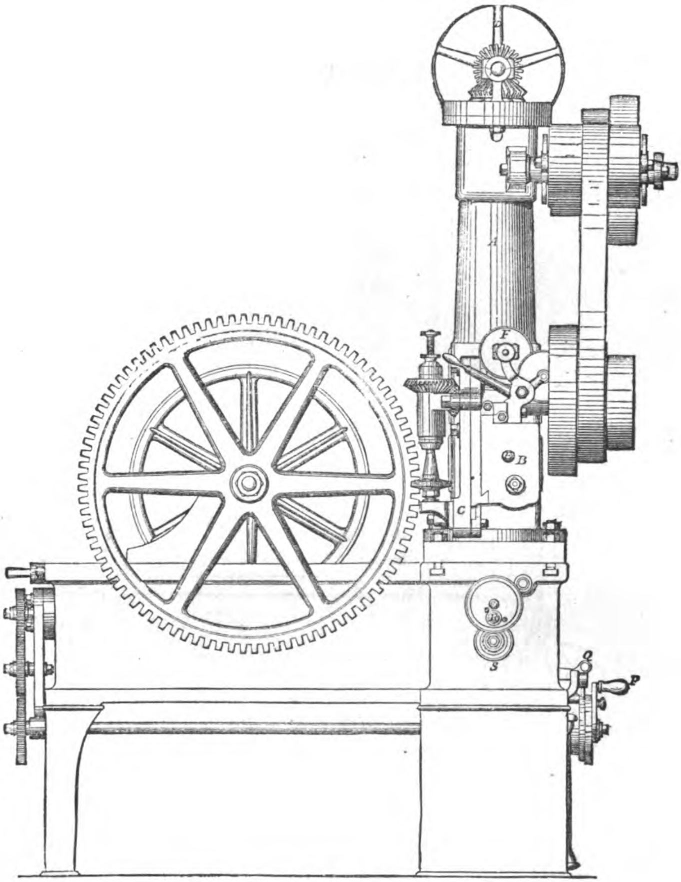
Mode of dividing.

The division is obtained by a tangent wheel and worm very carefully constructed, and the designated number of teeth is obtained by use of change wheels (a full set of which accompanies the machine), and the turning of the handle *P* (see cut) for change 1, 2, or 3 times, as may be called for on the schedule of division. This turning of the handle, however, and all other motions, are done by the machine itself. Thus, a blank wheel being put in place and the proper cutter adjusted to depth of teeth, length of stroke of cutter head, etc., the cutter will pass across face of wheel-cutting space between two teeth, will then return at a quick pace to the starting side of wheel, the blank will then be turned to present a second space to be cut, and the cutter will start its proper motion, all the changes being made by the machine itself, not by the attendant workman. To forcibly illustrate the merits of this machine, it may be said that in method of dividing, speed and power of cut it does not materially differ from other well-made gear cutters, but in quantity of

Quantity of work done.

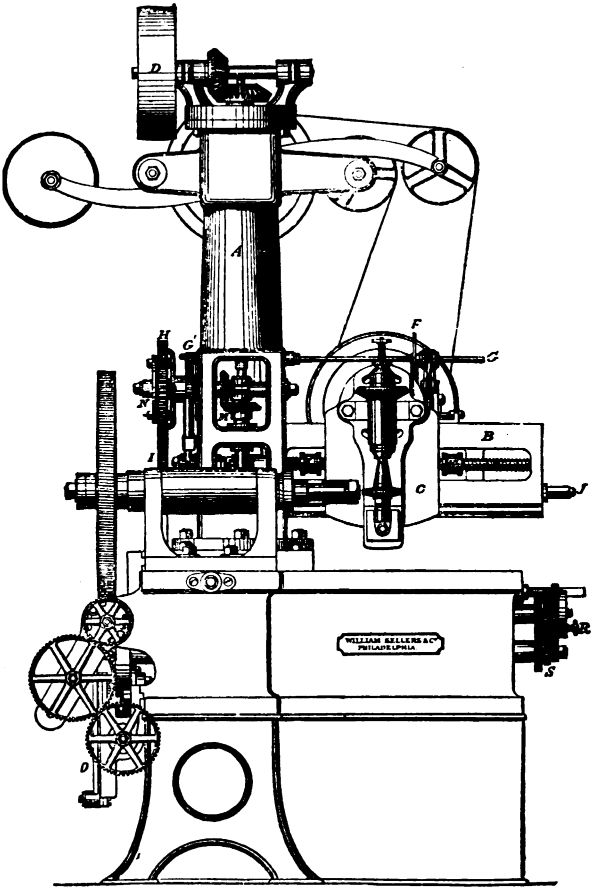
work done, one machine has been found, on similar work, to do one and a half times the work done by a

Fig. 80.



skillful man on a gear cutter of equal power operated partially by hand. In practice one man can advantageously attend four of these machines; each machine

FIG. 81.

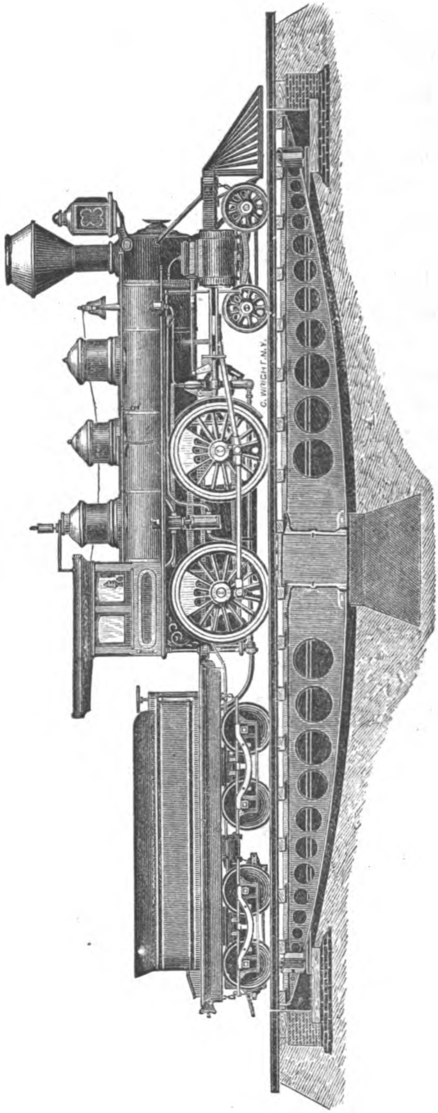


doing much more work than a hand machine, and really using but one-fourth of a man's time. Too much stress cannot be laid upon this as an example of

labor-saving machine tools, and as an argument in favor of such tools. Counter-shaft has 14 inches fast and loose pulley, 4 inches face for 3¾-inch belt; 120 revolutions per minute. **Speed.**

On pages 169, 170, we give two cuts in elevation. In Fig. 80, a spur wheel is drawn in position to cut. In cutting small wheels a number are placed side by side on the one mandrel and the pass of the cutter made over all wheels at once. When a long mandrel is used for this purpose a steady rest should be placed at its outer end; and when light wheels of large diameter, or any wheel that will spring sideways under cut, is being operated on, a rest block should be placed against the edge of the rim so as to resist the pressure of the cutter. The use of the friction feed discs, shown at *F* in cuts (80, 81), enables the feed speed to be varied to the proper amount to suit each case.

Fig. 82.



RAILWAY TURNING TABLES.

RAILWAY TURNING TABLES.

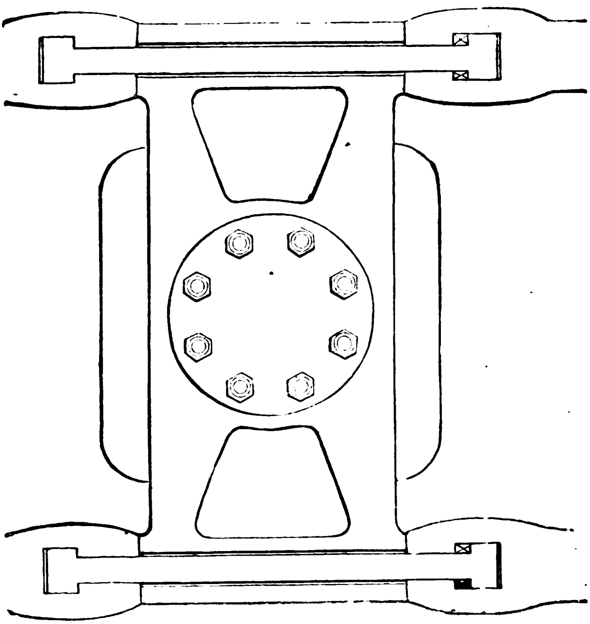
DIMENSIONS OF TABLES.

	60′ Table.	56′ Table.	54′ Table.	50′ Ex. heavy Table.	50′ Table.	45′ Table.	40′ Table.	30′ Table.	12′ Table.	9′ 4″ Table.	9′ 4″ Table.
Diameter of Pit . . .	60′ 1″	56′ 1″	54′ 1″	50′ 1″	50′ 1″	45′ 1″	40′ 8″	30′ 4″	12′	For heavy Freight Cars no Pit required.	For City Passenger Cars no Pit required.
Diameter of Circular Track	56′	52′	50′ 2¼″	45′ 10″	45′ 10″	41′ 4″	36′ 5″	27′	10′ 6″		
Distance from under side of rail on Table to top of Table Casting . . .	5	5″	5″	5″	5″	5″	5″	5″	5″		
Distance from top of Table Casting to top of Centre Stone	4′ 1″	4′ 1″	4′ 1″	3′ 10¾″	3′ 7¾″	3′ 7¾″	3′ 1¾″	2′ 5″	2′ 5″		
Size of Centre Stone . .	6′ sq. by 15″ thick.	6′ sq. by 15″ thick.	6′ sq. by 15″ thick.	5′6″ sq. by 15″ thick.	5′6″ sq. by 15″ thick.	5′6″ sq. by 15″ thick.	5′ sq. by 12″ thick.	5′ sq. by 10″ thick.	5′ sq. by 10″ thick.		
Height of rail on Table, when level, above rail on road	½″	½″	½″	½″	½″	½″	⅜″	¼″	¼″		
Height from under side of rail on road to top of Centre Stone	4′ 5½″	4′ 5½″	4′ 5½″	4′ 3¼″	4′ 0¼″	4′ 0¼″	3′ 6⅜″	2′ 9¾″	2′ 9¾″		
Height from under side of rail on road to top of Circular Track . . .	1′ 9½″	1′ 9½″	1′ 9½″	1′ 8½″	1′ 8½″	1′ 8″	1′ 8⅜″	1′ 8¼″	1′ 10½″		

RAILWAY TURNING TABLES.

SINCE our introduction of cast iron turn-tables for railroads, we have made many hundreds of them, of all sizes, and their use has extended over the greater part of both continents of America. They are simple in form, very durable, and easily put in place, requiring comparatively inexpensive pits, and turn with ease.

Fig. 83.

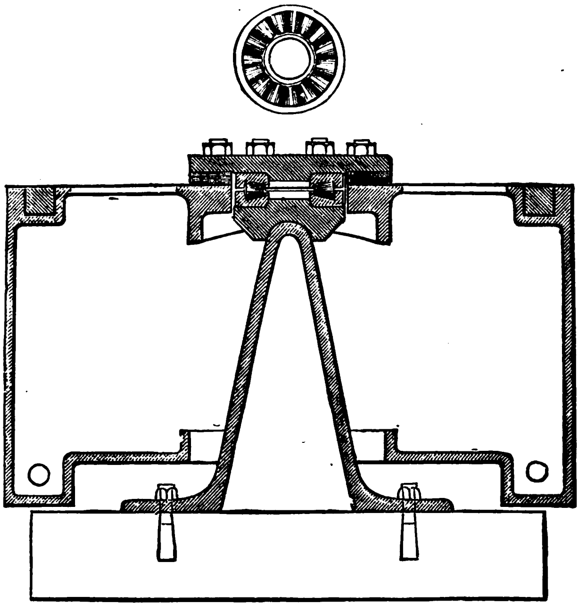


Arms. The table proper consists of four cast iron arms or beams, of proper shape for strength, firmly bolted, and secured to a cast iron centre box of requisite width.

Centre box. In the centre of this box is placed the peculiar pivot

upon which the table turns. At outer ends of the arms are cross girts carrying wheels to swing clear of a circular track rail, and upon which rail these wheels rest when the table tips, but they swing clear of it in turning. **Cross girts.**

Fig. 84.



In the centre of the pit is placed a conical centre post, with a broad base resting on a firm foundation of stone. This post extends nearly to the top of the centre box. The top of post is made hemispherical, and on it rests a cast iron cap, carrying a set of steel plates grooved and filled with conical steel rollers. The whole weight of table and engine rests on these **Post.** **Steel plates and rolls.**

steel rolls in turning. A cap of cast iron rests on the top steel plate, and to this cap the centre box is suspended on a circle of bolts, with a layer of wood between the box and cap. By taking out this wood and thinning it or adding more to it, the table can be adjusted in height. Upon the arms cross ties are laid, and to these ties the rail similar to that on the road is secured. The pit is usually built with a curbing of stone, and in the centre must be built a strong foundation of a size suitable to carry a top stone of the size prescribed in our list of dimensions. The pit is deepest in the centre, and grows shallower towards the circumference, ending in a level plateau for the reception of the circular track. This track should be carefully leveled, and should rest on well-laid sills,—stone or iron preferable to wooden sills. We have made gearing for turning these tables, but its application is worse than useless. One man, with a lever of such a length as will extend over the curbing of the pit, can, with ease, turn the heaviest engine. The power required to turn a table 50 feet in diameter, weighing over 24,000 pounds, was tried in our works, and it was found that one and one-half pounds pressure, applied at one end of the arms, was sufficient to start its motion from a state of rest. We make provision for adapting a cover to the entire pit, but it somewhat impedes the ease of turning; and in most cases the covered pit has been abandoned, even in round-houses, and the pit left open. The distance from top of curbing to circular track is so little—about twenty inches—that the pit may be crossed by stepping down into it, if necessary. It may be noted, also, that as the steel plates and rolls upon which the table turns are near to the top of the table, the pit

Layers of wood for adjustment.

Centre foundation.

Form of pit.

Circular track must be level.

Geared table.

Power required to turn.

Covered pit.

Depth of pit.

may be almost filled with water without interfering with the motions of the table, other than the resistance offered by the water. The introduction of steel centre plates and steel rolls in place of cast iron ones, as was our early practice, has made them very much more durable, and increased the ease of turning. Attention being paid to these rolls, they are practically indestructible. They should be occasionally cleaned, —once every three months, at least,—and at all times kept well oiled. Oil mixed with tallow, so as to be soft in cold weather, will answer a good purpose. In case of the breakage of any part by accident, such as an engine being run into the pit with the table out of place, etc., the broken parts can be readily replaced with new ones, as all the pieces are planed to gauge and are interchangeable; but if arms are broken, we should be advised if the broken one has key-ways at the large end where the T bolt fits into the recess in arm. In regard to diameter of table to suit any particular case, the larger diameters are the best, as the engine, either with empty or with full tender, can be most readily balanced; and it is necessary that the centre of gravity of the load be in all cases brought over the centre of the table, so as to have no appreciable weight on the circular track. When these tables were first made, 40 or 45 feet in diameter seemed to meet the case of the engines then in use; afterwards the increase of weight of rolling-stock compelled the introduction of 50 feet; still later of 54 feet, 56 feet, and 60 feet lengths. The 50 feet table having been placed in many round-houses and other positions where the larger sizes could not be conveniently used, the increase of weight of engines called for an extra heavy 50 feet table. This is designed to fill the want in such cases as the above, and

Water in pit.

Steel in place of cast iron for plates and rolls.

Must be kept clean and oiled.

Ease of repair.

Send description of broken parts.

Diameter of table.

40 and 45 feet tables.

50 and 60 feet tables.

Extra heavy 50 feet table.

is adapted to the heaviest engines that can be turned in such a diameter of pit; while the regular 50 feet table answers a good purpose for roads having engines of 25 or 30 tons weight only. The gauge of road has nothing to do with the width of table: hence we sell the same table for 3 feet and 3 feet and 6 inches gauge as we do for the 4 feet 8½ inches and 5 feet gauge. For 6 feet gauge we recommend our 54 feet size and over, as being wider in the centre box. The table 30 feet in diameter is intended for use in freight-depots for turning cars; has been used on coal roads for turning at "tips," and in one or two cases has been made with platform-scale attached, to permit weighing on the cars and load while on the table. We also make smaller sizes for shop use and for street passenger railways. The former of these is 9 feet 4 inches diameter, and is heavy enough to permit loads as great as can be readily got on that diameter being turned. The pit is shallow, and the table covers the entire opening. The latter table, for street roads, is lighter, can be readily put in place in the street, and offers no obstruction to the ordinary travel of carriages, etc. It is provided with a lock that is operated by keys in the hands of the drivers, and which cannot be tampered with by others using the street. This was called for to prevent boys from playing with the tables. The use of these small tables has extended to all our principal cities. Our remarks upon care of the steel rolls apply to these tables, which turn in cast iron conical rollers.

Gauge of road.

For 6 feet gauge.

30 feet table for cars.

Tables for shop use.

Shallow pit.

For street passenger roads.

Mode of locking.

We make to all sizes of tables an improved locking gear, when ordered; but in the majority of cases the purchaser arranges his own mode of locking them.

Locking gear.

CENTRAL SUSPENDED TURN-TABLE FOR SWING BRIDGES.

PATENTED { August 2, 1853. May 14, 1867. } EXT'D July 15, 1867.

We would request the attention of bridge-builders, engineers, and others to our Improved Central Suspended Turn-tables for Swing Bridges.

This system secures economy in construction, great durability, and admits of a high speed of operation at a comparatively small expenditure of power.

DESCRIPTION OF CENTRAL SUSPENDED TURN-TABLE.

The bridge is carried immediately by a double-webbed circular compound girder or drum, on which the weight of the bridge is evenly distributed, that is, carried at eight points equally divided in its circumference. The drum and its load are suspended from the centre pivot by a system of radial diagonal ties or bolts, so that the whole weight rests on the centre bearing, and is there carried by one or two series of cast steel rollers, of such number and so proportioned that the pressure against the friction surface is always within the limits of possible lubrication.

The large circle of wheels underneath the drum is used solely to steady the bridge when swinging, and it is not contemplated that any part of the actual weight of the bridge shall be carried on these wheels.

The swinging gear consists of one or two sets of pinions and shafts, having their bearings on the drum, and acting on a fixed circular rack, bolted to the wheel track. This swinging gear can be arranged to be operated by hand, steam, or other power.

THE ease with which locomotives can be turned on our improved cast iron turn-table for railway purposes, early led to the inquiry for the application of the same principle to tables of swing or pivot bridges. The success of this principle depends upon the entire weight of the superstructure being carried on the centre, and resting on the steel conical rollers placed there to receive it. With tables as ordinarily made this was not readily done. Hence, in practice, much of the weight of the bridge is carried on rollers placed on a circular track near to the outside

Entire weight on centre.

of centre pier. Our central suspended turn-table was designed to meet this want, and is applicable to all forms of swing bridges. We so arrange the structure as to insure the entire weight being carried on the centre plates, and we use the track rollers only to take the tip of the table. These track rollers we make the same for all weights of table, using more or less of them in the circle as the case requires, but never expecting that any of the load shall rest upon them. We provide a drum of wrought iron with top and bottom ends of cast iron, like a compound beam in structure; this drum is suspended from a centre box by means of diagonal tie rods and struts in alternation with counter rods from top of drum to base of centre box. Upon this outer drum the chords of bridge rest in such a way as to cause the load to fall in eight equidistant points on its circumference, thus insuring an equal distribution of the load. The rollers for circular track are carried in a wrought iron spider frame, and rest on cast iron segments placed in the stone work of the centre pier; to these segments are secured the toothed segments into which the pinions gear that do the turning.

Applicable to all forms of superstructure.

Track rollers to prevent tip

Circular.

Tie rods and struts.

Weight carried on eight points.

Track rollers.

Gear segments.

For bridges of 300 tons and under, the turning is always done by hand, but to larger sizes we have sometimes adapted steam turning machinery; in which case we so arrange the steam power in the centre drum or on the outside of it as the case may require, and all the motions of unlocking and loosening the ends of draw as well as turning are done at centre, and are effected by power, in either direction and at variable velocities. When turning by hand, two men can with ease turn a bridge of 260 tons weight. The chief engineer of the P. F. W. & C. R. R. reported

Steam machinery for turning.

Power required.

that a table of our construction, on the South Fork of the Chicago River, with a bridge of 260 tons weight, was used during seven months of the year 1868, as follows: **Example.**

Number of vessels passed	43,735
" " times swung	16,984
Travel of ends of bridge	1,077 miles.
" " of men in turning	1,517 "

This table has required no repairs, can be opened and closed by two men in 45 sec. each way. When asked for bids on these tables, we should know—

Dimensions required.

1. Weight of bridge, resting on table.
2. Distance from centre to centre of chords.
3. Whether two or three chords.
4. Nature of bottom chord (width and general character).
5. Available height for table, between high water and the under side of chord.
6. Distance from under side of chord to under side of rail in road, or to under side of roadway (should be about 8 feet, if possible).
7. If to turn by hand or steam power.

Parts furnished. As a general thing, we furnish only the centre casting, containing the steel plates and rolls, the centre post, the spider frame and track rollers, and the track with gearing bolted to the centre pin, as also the pinions, and their shafts and bearings, used in turning the bridge; the bridge-builders making the circular drum to drawings, which we furnish, and making also the system of struts and diagonal tie rods between the centre casting and the drum. But we will bid on the entire table if so desired. **Drawings furnished.**

RAILWAY TRANSFER TABLES.

THE most convenient form of building for locomotive and car shop, seems to be that in which independent stalls are arranged in line side by side. This calls for some convenient form of transfer or sliding table to shift engines or cars bodily sideways. We have, to meet this want, designed a wrought iron transfer table, formed of I beams riveted together, upon which the rails are laid. The structure is carried on four or six pairs of 36-inch wheels, resting on two or three tracks laid lengthways of the pit; the tracks being 6 feet gauge. The pit is lined at bottom, and very shallow, being only 11½ inches from base of rail on road,—*i.e.* from top of table to top of rails in pit; and as the pit may be paved level with the top of rails in it, it is practically but 11½ inches deep, and offers no impediment to those wishing to cross it. The frame of this table is well adapted for the reception of a vertical boiler and engine to move the table by power, and where much work is to be done this is economical.

We also make a cast iron table twenty-eight feet long, requiring a deeper pit, but arranged with gearing to move the table by hand.

WILLIAM SELLERS & CO.'S

SYSTEM OF SHAFTING.

SHAFTING.

We furnish, upon application, a price list, in which we call attention to the following mechanical advantages of our system, we having made the construction of Shafting a *specialty:*

1. All sizes are made to standard gauges.
2. The *Double Cone Vice Coupling* admits of quick and very easy attachment and detachment.
3. The *Double Braced Ball and Socket* hangers are light but very strong, and readily adjustable in every direction.
4. *Long Journal Bearings* held so as to always insure a uniform distribution of pressure over the entire length of bearing.
5. The appropriate distribution of metal in Pulley Castings, giving the greatest strength with the least quantity of material.

The introduction of a scale of fixed prices for every separate article, enables the consumer to know in advance the *exact sum* his work will cost, thus giving a great advantage over the purchase by the *pound*, the amount of which is generally indefinite. Purchasers of our Improved Shafting will make not only a direct saving in first cost, but a continual one, by the acquisition of a well-constructed and easy-running system for the transmission of power, very neat in appearance, and as light as is consistent with the requisite strength; our extended experience having enabled us to establish correct proportions without any undue expenditure of material.

Fixed scale of prices.

HAVING been engaged since the year 1848 in the manufacture of shafting and mill gearing, during which time we have introduced a fixed scale of prices for the various articles comprised under the name of "Shafting," we have from time to time made important improvements, and, by the introduction of special tools, been enabled to very much reduce the cost of the articles needed in this line.

Shafting considered as a machine.

In any large factory the shafting, with its couplings, pulleys, and other adjuncts, considered as a machine to transmit motion, is most frequently the largest in the establishment: hence every consideration of economy

requires that it should do its allotted work with the least possible loss of power in the transmission. It calls for economy in first cost, and economy in use.

The generation of power to be expended in operating machines to do work costs something; it may cost much money in fuel consumed, or it may cost something in energy expended. In any case, the more perfectly the whole power is transmitted to the work, the more profitable will be its use.

History of improvements.

It is a noteworthy historical fact, that economy in the generation of power in the motor, and economy in the utilization of the power in the machine, have been in most countries far in advance of the economical transmission of power from one to the other. Years ago there were excellent models of water-wheels, and by them were driven machines of surprising ingenuity, but the power was conveyed by means of cumbersome wooden shafts upon which were wooden drums for the driving belts; gearing too, made of wood, slow-moving, awkward contrivances for the purpose, and very wasteful of power.

Early engineers in iron took model from the practice with wood.

In the progress of the art, it is quite evident that early engineers in iron took their ideas from what had been done in wood. They copied in iron what had been the practice in wood. Cumbersome, slow-moving iron shafts took the place of slow-moving wooden shafts. Gear wheels were used to transmit the power from the motor to the shafts, and from shaft to shaft in the various rooms and situations requiring power; while belts or bands from pulleys were only used to transmit the power from the shafts to the individual machines. The practice of high-speeded shafts, and the entire substitution of belting for gear wheels, belong essentially to this country.

Belts *vs.* gear-wheels.

The value of high speed in belts has been long known in England and in some parts of Europe, and many wonderful examples there exist of its application. These examples are, however, exceptional, and have not come to be general mill practice.

Mr. R. Willis.

It may be well to note that in a book published in London in 1841,—"Principles of Mechanism," by Robert Willis, M.A., F.R.S.,—mention is made of the use of belts, and what was the practice in America at that time, in these words:

"Belts, on account of their silent and quiet action, are very much employed for machinery in London, to avoid nuisance to neighbors. It appears, also, from a recent work,* that the use of belts is greatly extended in American factories. In Great Britain the motion is conveyed from the first moving power to the different buildings and apartments of a factory by means of long shafts and toothed wheels, but in America by large belts, moving rapidly, of the breadth of 12 or 15 inches, according to the force they have to exert."

What Prof. Willis says in regard to American practice has continued to be the practice since this was written, but has been vastly extended; here the employment of wider belts and faster-running shafts has become more general, while this extensive use of belting obtains in very few cases abroad, even up to the present time.

Use of gear wheels limits the speed.

The use of gear wheels to transmit the motion from one shaft to another limits the speed at which the shafts may be run. Too high a speed causes the teeth to break even when doing no work,—*i.e.* when the load

* Cotton Manufacture of America, by J. Montgomery, 1840, p. 19.

is off. With belt-driven shafts any convenient speed may be obtained, and thus the smallest possible size of pulleys on the line be used. To obtain the high speed found advantageous in modern mill practice, the shafts must be straight and truly cylindrical; they must be united by couplings that hold them firmly, and be provided with bearings that will maintain the shaft in a true line, so as with proper lubrication to reduce the friction to a minimum. Since the introduction of turned iron shafts, a great many contrivances have been used to unite shafts. It must be borne in mind that the coupling should be of such a nature that the strength and rigidity at the joint shall be as great, if not greater, than in any part of the line, so that if the line be subjected to flexure, it will bend anywhere else than in the coupling. In England, up to the present time, it is considered good practice to make the ends of all shafts larger than the body of the shaft by forging, and then to these enlarged parts secure the couplings by various and sometimes expensive means. Shafts so enlarged at the ends cannot be made to receive carefully bored pulleys, unless the pulleys be made in halves, bolted together upon the shaft. Shafts come from the rolling mill, of certain merchantable sizes, as round iron. These round bars, when turned so as to be of uniform diameter, should be united without the extra cost of enlarging the ends.

With belts high speeds are possible.

Requirements of a good coupling.

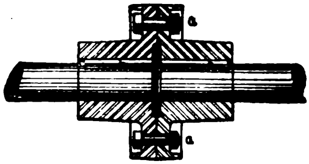
English practice as regards couplings.

The first really good coupling used for this purpose was what is known as the plate coupling. This coupling (Fig. 85) consists of two plates, with stout hubs, fitted with great care to the ends of the shafts to be coupled, and the plates then held together by very carefully fitted bolts, *a a*, which are turned and fitted

Plate coupling.

into reamed holes. There are also keys (*b*) provided to prevent the couplings turning on the shafts. This,

FIG. 85.

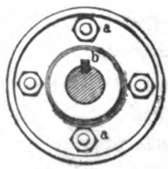


when well made, is an excellent form of coupling, but it has manifest disadvantages; its first cost need not be very great, but it requires too much care in fitting.

Use of keys in plate coupling.

We have said that keys are used to prevent its turning. They must be put in as a precaution, not as an actual necessity, and must be made to fit on their sides, not on their top or bottom. (See Fig. 86.)

FIG. 86.



How plate couplings are fitted.

The coupling is usually bored to some standard size, say $\frac{1}{16}$ of an inch less in diameter than the body of the finished shaft. The ends of the shaft are turned, in the case of a 4-inch shaft, .015 of an inch larger than the hole in the coupling; key seats are cut in the shaft and in the coupling, and a parallel

Key.

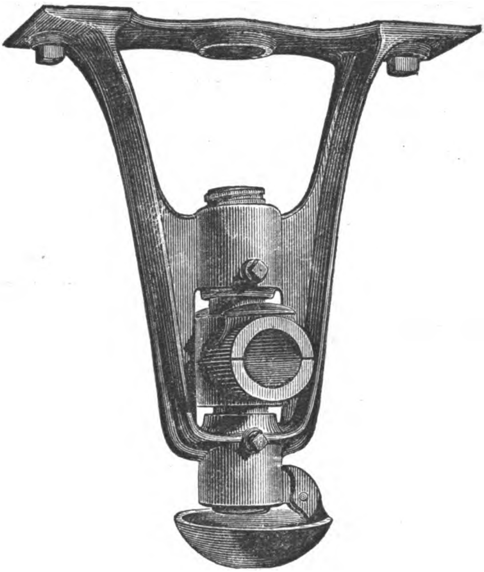
key fitting sideways, not top and bottom, is laid in the keyway in shaft, and the coupling forced on by a powerful press with say from 20 to 30 tons pressure.

The effect of taper keys.

If a plate coupling be so fitted as to slide on and off easily, and an attempt be made to hold it in place by a taper key, fitting top and bottom, the pressure on the shaft will be on two opposite lines only, and

sooner or later such coupling will work loose. To drive in a taper key is the very surest way to break or burst the surrounding metal, or at least make it run out of true. We cannot too strongly condemn the use of taper keys in all similar cases. A plate coupling, when properly fitted, requires great force to remove it, when its removal is needed for the placement of pulleys on the line, and frequent removal in-

FIG. 87.



jures its fit. It also necessitates the use of open-sided or hook hangers, as the coupling cannot be put on after the shaft is in place. These hangers, for equal strength, require double the metal used in a hanger with metal on both sides of the box. (See Fig. 87.) The greatest objection, however, to the use

Obliges use of open-sided hanger.

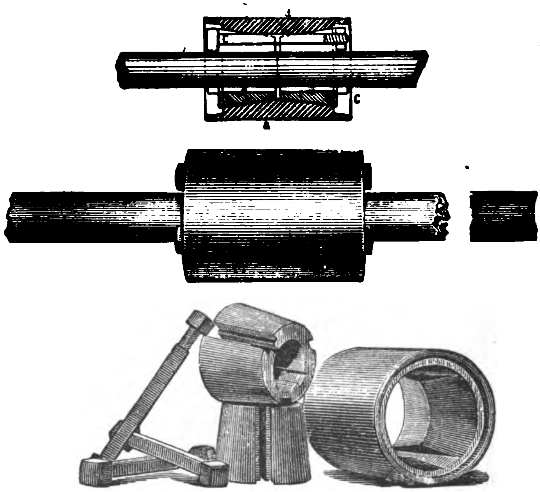
of this and similar kinds of coupling is in the fact that skilled labor is required to insure accurate fits, and that no practicable system of inspection will enable the mill owner to know that the fits are good ones. The working out of any shaft from its coupling may result in the fall of the section of shaft, the breaking of valuable machinery, or, too often, the loss of life.

No inspection will insure perfect fits.

1856.

Previous to the year 1856 we used the plate coupling exclusively, with a hanger made open on one side. Desirous of insuring accuracy of fit of coupling

FIG. 88.



Patent coupling.

independent of the skill of workmen, we, during that year, introduced a coupling which, while it fills all the requirements of absolute security, can be cheaply made, and admits of ready removal and ready adjustment when pulleys, etc., are to be added or changed.

This coupling (Fig. 88), which we have called the double cone vice coupling, consists of three principal parts,—an outer sleeve, *a*, and two inner sleeves, *b b*. The outer sleeve has its interior surface made like two frustums of cones, with the apex of each meeting in the centre of the sleeve. *b b* are conical sleeves, bored to fit on the shafts intended to be coupled, and having their outer surfaces so turned as to fit into the conical holes of the outer sleeve, *a*. The cones *b b* have three equidistant square slots cut in them, and there are corresponding slots on the inside of the outer sleeve. These slots are to receive square bolts, *c c c*. The sleeves *b b*, when put into place in the outer sleeve, will not quite meet,—*i.e.* they are too large to go in all the way. They are, however, split, each one, in one of the square slots at *d*. This split makes them elastic, and if they be forced into the conical holes they will contract, and thus diminish the size of the centre holes. The square bolts, *c c c*, while they serve as keys to prevent the inner sleeves from turning, also serve as a means of drawing the conical sleeves towards one another; so that if the ends of shafts be in these sleeves, such ends will be pinched or held fast by the pressure, and that in proportion to the force used in screwing up the bolts.

Outer sleeve. **Inner sleeves.** **Bolts.**

An important feature to be noted is, that one cone cannot be drawn in with any more force than the other one; the resistance is the pressure on the shaft ends. The pressure on both ends of shafts in such a coupling must be equal, and is under the control of the person using and applying the coupling. The shafts need not be of exactly the same size; shafts of an appreciable difference in size may be as firmly held as if they were of the same diameter. Key slots are

Equalizes the pressure on each end.

provided as a precautionary matter, as shown at *e e;* but the keys must, as we have before stated, fit sideways, and not touch top or bottom. That the shafts united by this coupling need not be of the same diameter is a very important consideration, and leads us to dwell for a moment on an important feature of shafting, viz., its *cost.* Machines can readily be constructed to turn bars of round iron in the condition they come from the rolling mill to a nearly uniform size, with great rapidity and at a very small cost. The expression, *nearly uniform*, we use advisedly. We mean that shafts can be turned so that a standard hardened gauge can slide over them and seemingly they will be of uniform diameter; but a careful measurement would show them to be only approximately alike in size. They are what may be called commercially accurate. This commercial accuracy represents a certain cost of production. Absolute accuracy, were such a thing possible, would represent a cost many times greater. Commercial accuracy is attainable by machines and by unskilled labor; absolute accuracy would involve more costly processes and the utmost skill of the most experienced workmen. When the plate coupling was in common use, the bodies of the shafts were made of one size, and the coupling ends reduced by skilled workmen to a smaller size and carefully fitted to the coupling. It was this fitting that was costly. With the cone coupling this fitting is dispensed with, and shafts are sold as they come from the turning machines. An adjustable coupling, to be good for anything, must clamp each end uniformly.

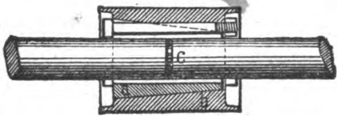
Commercial accuracy.

There are, and have been for years, many forms of adjustable couplings in use which do not fill this

requirement. As an example, one shown in Fig. 89, in which one long conical sleeve, *a*, fits in a conical hole

Single cone coupling.

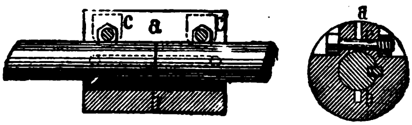
FIG. 89.



in the outer sleeve, *b*, and the shafts to be coupled meet in the centre, at *c*. The cone (*a*) being split as are the cones in the coupling before described, the conical sleeve, when forced in, will be compressed upon the two ends of the shafts, provided these ends are of exactly the same diameter; but if one is ever so little larger than the other end it will be held, and the smaller end will be loose, and, what is more, no amount of pressure exerted by the bolts will make such a coupling hold the smaller one as firmly as the larger end. So, again, a coupling made as shown in Fig. 90, which represents a plain cylindrical sleeve,

Require ends of shafts to be of uniform size.

FIG. 90.



split through at *a* and partly through at *b*, so as to render it elastic, and is compressed by bolts *c*,—such a coupling will hold shafts of exactly the same size, but will produce an unequal pressure on shafts of slightly different diameters. In practice, this latter coupling is made to hold by means of a peculiar key,

Sleeve coupling.

which extends over the two ends of the shafts to be united, and is provided with pins at its end, fitted into holes drilled in each shaft.

While on the subject of adjustable couplings, it may be well to remark that in putting them on the shafts they should be put on with a view to removal. All parts should be well and carefully oiled, so as to avoid all chances of their rusting fast. And in event of required removal it is best to slack up the bolts, and if not then loose, a few blows upon the outer shell with a billet of wood may start it loose. In case of the double cone coupling, a wedge, say a cold chisel, driven into the split in inner cone always loosens the cones and frees the coupling.

How to remove patent coupling.

Test of the cone coupling.

When the double cone coupling was first made, it was subjected to severe trials to test its utility. The experiment was made by coupling two shafts, which were placed on three bearings 10 feet apart, the coupling being near to the middle one. The hangers were so placed as to bend the shaft 1¾ inches out of line. These shafts so coupled were then made to revolve 250 revolutions per minute for many weeks during working hours, and yet the coupling did not loosen under this severe strain. Since that time they have been made by thousands, and are in use in all parts of our country.

Next to the proper means of uniting the shafts, come the devices to sustain the shafts and permit them to revolve freely on their axes.

Mr. E. Bancroft.

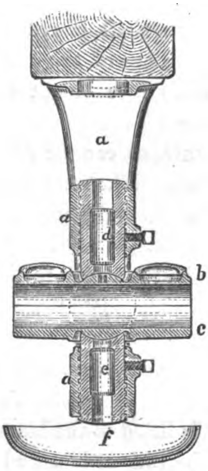
Swivel hanger.

About thirty years ago, Mr. Edward Bancroft, then engaged in the machine business in Providence, R. I., invented what was called the swivel hanger. In order to insure the weight of the shaft being received over the entire length of the box, he hung the box in a

kind of universal joint and made its axis of vibration coincide with the centre of the box. This permitted the use of longer boxes than were heretofore practicable, and the pressure per square inch on the surface was lessened. Before the introduction of the swivel hanger, rigid bearings were the only kind used,—we mean bearings which could not adjust themselves to the positions of the shafts,—and such rigid bearings are still used in Europe. When Mr. Bancroft had demonstrated the great advantages of the swivel or self-adjusting hanger bearing, he showed it to most of the prominent machine builders in the New England States, and tried to introduce it generally; but not one could be found who was willing to undertake its manufacture. They characterized it as a needless piece of refinement, and far too costly to be generally used. Mr. Bancroft afterwards, in connection with Mr. William Sellers, under the firm name of Bancroft & Sellers, manufactured this hanger, and introduced it extensively.

Rigid bearings.

FIG. 91.



This swivel hanger was afterwards superseded by what is called the ball and socket hanger, now in almost universal use in this country, which is the same in principle but differs in detail. Various circumstances have, from time to time, caused modification in the form of the supporting frame, but the principle has remained unchanged. Fig. 91 shows a section of the modern hanger. The part marked *a*

Ball and socket hanger.

Frame of hanger.

is the frame or hanger; *b*, the top box, and *c*, the bottom box, the two halves united, forming what is called the "box,"—*i.e.* the journal box or bearing: the bearing in which the shaft rotates. This box is provided, top and bottom, with spherical surfaces, so placed as to be, in reality, portions of a sphere which has its centre in the centre of the axis of the box; *d* and *e* are what are called the plungers. These are screwed into the frame, and are provided with cup-shaped ends to clasp the spherical parts of the box. The box can rock to a limited extent in every direction in these cup-shaped ends. The plungers serve a double purpose: 1st, of providing the socket for the sphere to roll in; 2d, to permit of a vertical adjustment of the entire box to bring them in line one with another; *f* is an oil dish to catch the drippings from the box. It is quite evident that a shaft placed in such a bearing will control the positions of the box, and will press uniformly over the entire length of the box.

Plungers.

Oil dish.

This is a very important feature, as can be seen when compared with a rigid bearing. When hangers, having their boxes or bearings made in one piece with the hanger, are to be attached to beams, some distance from each other, they must be bolted securely to the beams in such positions as will insure all the boxes in the entire series being in line one with another, so that a shaft placed in the boxes will rotate freely without binding. It will readily be seen that to do this the foot of the hanger must be carefully fitted to the beam, so that a line stretched through the various boxes will touch all parts of each. This involves great skill and much time in putting up. This skill and time is at the cost of the purchaser and user of the hanger.

Trouble of setting rigid hangers.

Increase of cost to user.

Then when they are in place, the warping or twisting or sinking down of any one beam will throw the bearing out of line, and thus tend to cramp the shaft in its bearings. With the ball and socket hanger, care is only required to bring the hangers in line sideways; the plungers admit of adjustment vertically, and the shafts twist the box into line with itself. Thus all skilled labor is dispensed with in putting up, and possible adjustment is at all times practical.

Ease of putting up ball and socket hangers.

But the most important feature of this hanger is the possibility of using longer bearings or boxes than with the rigid hanger. With the latter, the longer the box the more difficult to line, and the more useless friction if out of line. With the swiveling principle, the box adjusts itself, and thus takes a uniform bearing over its entire length. This is of the greatest importance, and influences the material forming the box. With a pressure not exceeding fifty pounds per square inch, and oil well distributed over the surface of the box, the metal of the shaft will not touch the surface of the box; it will run on the oil used as a lubricator. The oil under this pressure is not squeezed out, and maintains its lubricating properties for a long time. Hence, if the shaft does not touch the box, it matters little what metal is used in making the box. Cast iron is the cheapest and most readily worked into shape. It is, in reality, the most durable of the metals for the purpose if kept well oiled, but the poorest if allowed to run dry. Brass or bronze has been used to a great extent, and lately a metal called Babbitt's metal has met with favor as a lining metal for boxes; but we may mention that a cast iron nut on a lead screw of a lathe will outwear a brass nut two to one, and cast iron gear wheels are

Pressure on the bearing.

Oil is not squeezed out.

Babbitt's metal.

much more durable than brass under limited pressure; that is, if the pressure on two pairs of wheels, one pair iron and one pair brass, be the same, and the pressure on both be within the limit at which cast iron will run without breaking, the cast iron wheels will last much the longest. Brass is resorted to for greater toughness, not for durability. The soft metals, under the general term of Babbitt's metal, are cast into recesses in journal bearings, and are extensively used. There are places where its use is advantageous, but for shafting purposes its use is to be discouraged. All soft metals, while they do not cut when permitted to run dry, in the way cast iron is sure to do, yet they serve to catch the grit and dirt in the atmosphere which finds its way in with the oil, and the soft metal holds these little sharp particles, and thus gradually grinds down the shaft running in it. When it is desired to grind down a cylinder of hard metal, lead clamps are applied to its surface very like journal boxes, and into these clamps oil and emery is fed. The lead will hold the emery, and thus reduce the size of the hard metal without serious wear on its own part. It is claimed that boxes cast with a recess to hold the soft metal can be used as they come from the foundry, and thus all labor of boring and fitting be dispensed with; the shaft can be laid in place on the cast iron shell, and soft metal, melted in a ladle, can be poured in, thus filling the recess and insuring a fit. This sounds very plausible; but the box with its recess must be rather larger, to be of equal strength, with one cast without such recess. Babbitt's metal costs much more than cast iron; we may safely say it costs ten times as much. The melting and pouring takes time, which costs money. Now, in point of

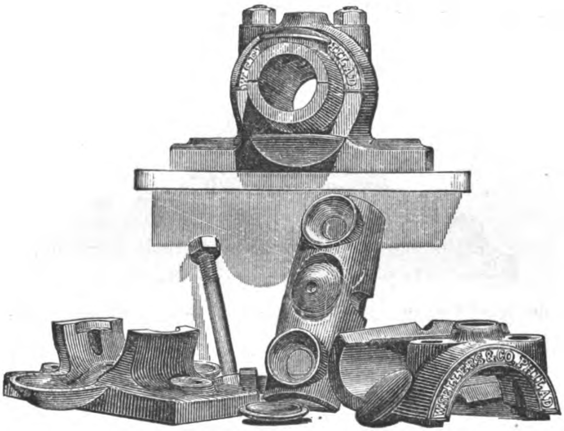
Soft metal linings hold grit.

Comparison of cost of soft metal bearing.

fact, a pair of cast iron boxes can be planed on their faces, then bored to fit the shaft, and grooved for oil passages, for less than half of what the least quantity of soft metal would cost that can be used in such a box.

What we have said in description of the modern hanger holds good in the various forms of bearing, suited to various uses, where hangers are not admissible. Thus, when the shaft is to be carried by stone piers, not likely to lose their horizontal adjustment, or in case of vertical shaft, pillow blocks are used in place of hangers. (See Fig. 92.) The box is furnished **Pillow blocks.**

Fig. 92.

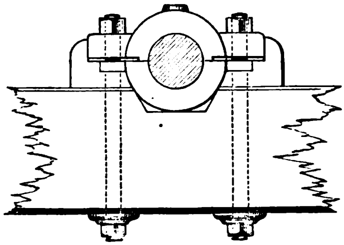


with spherical surfaces to fit in sockets in the casting or frame; it is self-adjusting as to line, but cannot be raised or lowered, as in the case of the hanger. I takes the place of what is known as the clamp box (see Fig. 93), and of any rigid bearing not adjustable. **Takes the place of clamp boxes.**

Pillow blocks are sometimes used in connection

with cast iron wall plates upon which they rest, and are secured by bolts. (See Fig. 94.) This same com-

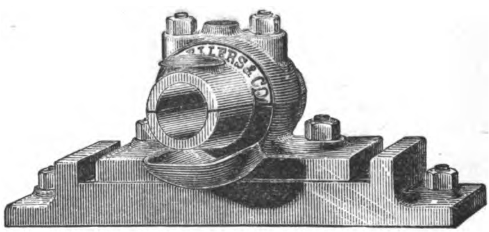
FIG. 93.



Use of pillow block on head shafts.

bination inverted, with an oil dish on the cap of the pillow block, is now sometimes used to carry the head

FIG. 94.



shaft of long lines, as it admits of the very heavy head shaft, with large pulleys, being hoisted into place and then secured by the cap and bolts. Head shafts, or the first shaft of any line, usually rest in two bearings. Fig. 95 shows such an inverted pillow block. Sometimes it is requisite to build bearings in a wall, in which case what is called an arched wall box (Fig. 96) is used in connection with the pillow block. Very often it is advisable to support the line shaft from the face of a wall, in which case pillow blocks, secured to knees, are very convenient. (Fig. 97.)

Inverted pillow block.

Arched wall box.

Brackets for pillow blocks.

Fig. 95.

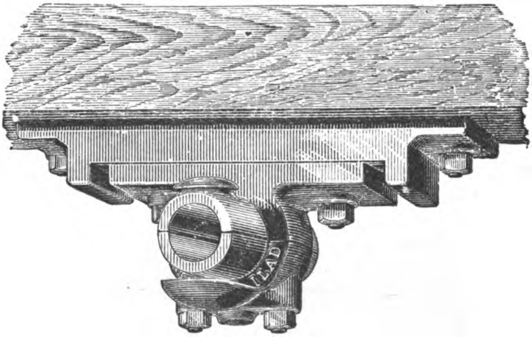


Fig. 96.

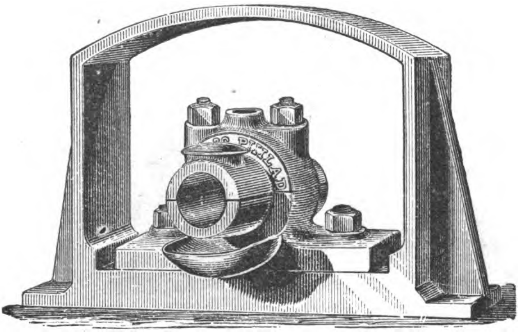
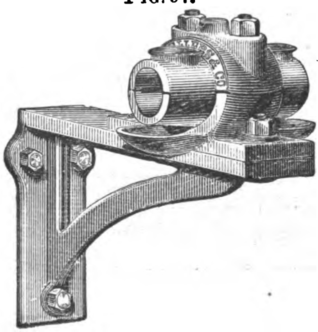


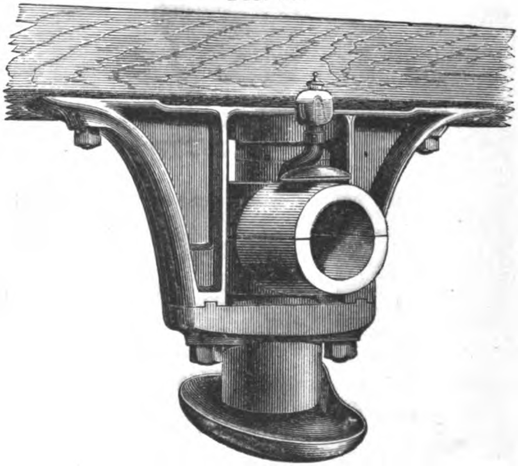
Fig. 97.



While the inverted pillow-block, as shown in Fig. 95, answers some of the requirements of a head-shaft bearing, yet it does not permit of vertical adjustment when in place on the beam or footing-piece, nor can the top half of the box be removed without lowering the entire shaft. We therefore recommend for this purpose what we term our Head-shaft Hanger, as is shown in Fig. 98.

Head-shaft hanger.

FIG. 98.



The lower part of this hanger is attached to the frame by bolts after the manner of the cap of a pillow-block, and is tongued into the frame to add stability to the frame. The box or bearing is made precisely like those in our regular line hangers, and is held in place by screwed plungers, as in the hangers. These plungers permit a limited amount of adjustment, and thus greatly facilitate the erection of the work, and the lining up of the shafts if the building to which it is attached settles unequally. One of the principal

Bottom of hanger takes off.

Adjustment of hanger.

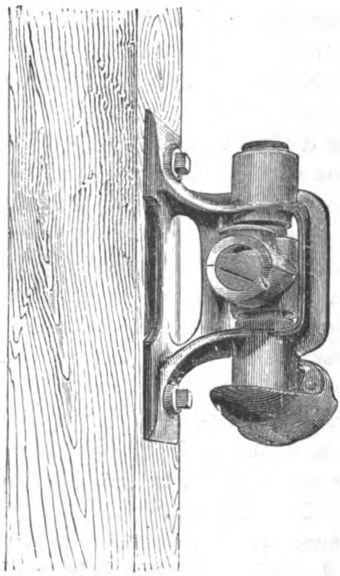
advantages offered by this form of hanger, apart from the ready placing of the head-shaft with its pulleys in position from below, is that the top half of the box can be removed, if necessary, without disturbing any of the adjustments. This facility of getting at the bearing while the shaft is running is of great importance, particularly if the box becomes heated by reason of too great belt-strain on the pulleys, or from neglect in oiling. The top half of the box being removed, appliances can be resorted to to cool the heated journal or otherwise correct the evil. **Removal of top box.**

We deem it of the utmost importance that oil should be fed to the centre of all journal bearings. It is not sufficient to oil a long box at two places, one near each end. The oil should be fed into the centre of the top box. With this in view we arrange a projecting arm, seen in the cut, Fig. 98, to carry the glass oiler, and thus bring it outside of the beam to which the hanger is attached. In this form of head-shaft we also have accomplished the desirable result of obtaining an adjustable hanger of short drop for large sizes of shaft, our 6″ hanger being of 11-inch drop, thus working in well with the line hanger, which in cotton and woolen mills are generally made of 11-inch drop, or eleven inches from the centre of the shaft to the base of the hanger where it is attached to the beam. **Oil fed to centre of box.** **Drop of hanger.**

In case it is required to work in with hangers of deeper drop, it can be readily blocked down with a wooden footing-piece, or attached to an iron bed-plate, if such an arrangement is deemed preferable. The oil dish below the hanger is loose and can be removed to empty, it being attached to the hanger by a single pin.

Post hanger. Fig. 99 shows an example of a hanger to be fitted to a post; it is called in that form a post hanger. It is, in all essential particulars, like the ordinary hanger, so far as its adjustment and swiveling principles are concerned.

Fig. 99.



Durability of cast iron bearings. As an illustration of the durability of cast iron bearings for shafting purposes, we may mention that some time since we took occasion to examine a bearing in which had been running, for sixteen years, a 4½-inch shaft, with a pulley 72 inches diameter and 20 inches face, close to the bearing, taking all the power from an engine of 16-inch cylinder, 3-foot stroke, making 50 strokes per minute,—say transmitting fifty-two horse-

power. This bearing showed a bright surface over the extent of one-third of the circumference of the shaft on the bottom half box. The box had been originally made to fit the journal loosely, and it had not worn enough to make it fit over one-third of the circumference of the shaft. In the use of cast iron bearings, lubrication must be attended to, else the bearing will soon be cut and rendered useless; but lubrication is so easy, and so little oil is needed for the purpose, that there can be no reasonable excuse for neglect. We provide every box with large cavities in each end of the top box; these cavities are called tallow cups. They should be filled with tallow and oil, mixed so as to be of such a consistency as not to be fluid in warm weather. Should the journal heat from any cause, this same solid lubricant will melt, and, running into the bearing, will protect it for the time being. The box should be oiled in the centre; and oil holes are provided for that purpose in the recess around the spherical portion of the top box. There is also a hole in the very centre of the ball on top, and the top plungers, which rest on the ball, being hollow, a self-feeding oil cup can be placed on top, and thus deliver oil regularly to the bearing. As to the quantity of the oil needed, we would remark that shafts running in self-adjusting hangers, with bearings four diameters long, at a speed of 120 revolutions per minute, require, on an average, $2\frac{2}{10}$ fluidounces of oil per bearing for six months' oiling; and self-feeding oilers, placed on top, should not deliver any more than this quantity.

Lubrication.

Tallow cups.

Quantity of oil required.

From time to time a great deal is said about self-oiling boxes. By this term are meant boxes that are made to contain oil in some reservoir, usually under

Self-oiling boxes.

the shaft, and from which reservoir oil is fed to the shaft, and then allowed to run back into the reservoir and thus be used over and over again. It is said that bearings in self-oiling boxes have been made to run for a year or more without attention; but we have never known a self-oiling box to be made to work well with so little oil as $4\frac{4}{10}$ fluidounces in it. Some of them hold a pint each. One pint is 16 fluidounces, quite enough oil to last four years, if properly applied; and yet it would never do to trust that quantity of oil for that time, as it would become deteriorated by age. Self-oiling boxes are rather more costly, and take more oil to run them, than properly made bearings oiled by hand. Self-oiling boxes are good things to sell,—better than to use; they are good things to talk about to those who do not know what true economy in oiling is. **Glass oil cups.** Glass oil cups above the bearing, feeding oil at such a rate as to consume $2\frac{1}{4}$ fluidounces in six months, to say hangers for $2\frac{1}{2}$ shafts, are the best, and oil fed at this rate will not run out of the box ends, but will just supply the waste from consumption.

All shafts, long or short, must be provided with some means of preventing end motion. Line shafts **Collars.** should have one pair of collars fitted to one of the bearings only. We recommend them to be placed on the head shaft,—that is, on the largest shaft which receives the power,—and thus control the position of the entire line; more collars are apt to cause needless friction. When shafts are collared, the collars should be fast to **Loose collars.** the shaft; loose collars held in place by set screws are sometimes used, but are more expensive and cumbersome than the fixed or fast collars. Some engineers prefer necking in the head shaft to some smaller size in the journals. Suppose the first or head shaft re-

quires to be made of iron 6½ inches diameter, to sustain the driving belt. This shaft might be necked in, and be carried by bearings say 5½ inches diameter, and the ends still further reduced to the size of the shaft to be coupled to it. This practice of necking in the bearings of the head shaft is common in modern cotton-mill practice, and has the advantage of diminishing the velocity of the surface motion and of the shaft in the box; for by diminishing the diameter we diminish the speed of the rubbing parts, and the tendency to heat is much increased with increase of velocity. **Necking in of shafts.**

To determine the size of shafts for the transmission of a given power, a safe formula is $D = \sqrt[3]{\frac{P}{R} \times 125}$, D being diameter of shaft, P the horse-power, and R the number of revolutions per minute. This gives a shaft strong enough to resist flexure, if the bearings are not too far apart. The distance apart that the bearings should be placed is an important consideration. Modern millwrights differ slightly in opinion in this respect: some construct their mills with beams 9 feet 6 inches apart, and put one hanger under each of the beams; others say 8 feet apart gives a better result. We are clearly of opinion that with 8 feet distance, and shafting lighter in proportion, the best result is obtained. The tendency now is to increase rather than diminish the speed of line shafts; and good practice is to run shafts for machine-shop purpose at 120 revolutions, for wood-working machinery at 250 revolutions, and for cotton and woolen mills at from 300 to 400 revolutions per minute. Hollow or pipe shafting has been made to run at 600 revolutions per minute very satisfactorily. This kind of shafting is, however, too costly to be generally introduced. **Formula for size of shaft.** **Distance apart of hangers.** **Speeds.**

Mr. James B. Francis, of Lowell, says that since the **Mr. James B. Francis.**

decrease of the water-power in that town, or rather the rapid increase of the factories, they have been obliged to economize their power, and they are doing so by using smaller shafts at higher velocities, and have even made extended lines only $1\frac{1}{4}$ inch in diameter. They so arrange the mill as to secure a hanger close to each transmitting pulley. The torsion in long lines limits the smallness of the shaft used, and in all probability the best result will be found to be obtained in the use of not less than $1\frac{3}{4}$-inch diameter for the smallest line shafts in cotton mills.

There are now running in some factories lines of shafting 1000 feet long each. The power is generally applied to the shaft in the centre of the mill, and the line extended each way from this. The head shaft being, say 5 inches diameter, the shafts extending each way are made smaller in proportion to the rate of distribution, so that from 5 inches they often taper down to $1\frac{3}{4}$. In coupling shafts of different sizes it is customary to reduce the end of the larger one to the size of the smaller shaft, and then to use a coupling suited to the smaller size.

Coupling shafts of different sizes.

FIG. 100.

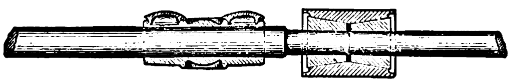


Fig. 100 shows an example of this method of reducing the larger shaft to the size of the smaller one. The rapidity with which the reduction of the size of the sections is made must depend, in all cases, on the distribution of the power. For instance, if a line of any length whatever receives its power at one end and transmits the same amount of power at its other end,

such shaft must be of uniform diameter; but if it distributes its power at regular intervals along its length, the shaft may be made in sections of a size proportioned to the power given off.

Disadvantage of too small shafts.

When very long lines of shafting are constructed of small or comparatively small diameter, such lines are liable to some irregularities in speed, owing to the torsion or twisting of the shaft as power is taken from it in more or less irregular manner. Shafts driving looms may at one time be under the strain of driving all the looms belted from them, but as some looms are stopped the strain on the shaft becomes relaxed, and the torsional strain drives some part of the line ahead, and again retards it when the looms are started up. This irregularity is in some cases a matter of serious consideration, as in the instance of driving weaving-machinery. The looms are provided with delicate stop motion, whereby the breaking of a thread knocks off the belt shifter and stops the loom. An irregular driving motion is apt to cause the looms to knock off, as it is called, and hence the stopping of one or more may cause others near to them to stop also. This may in a measure be arrested by providing fly-wheels at intervals on the line shaft, so heavy in their rim as to act as a constant retardant and storer of power, which power is given back upon any reaction on the shaft, and thus the strain is equalized. We mention this, as at the present time it is occupying the thoughts of prominent millwrights, and the relative advantage and disadvantage of light and heavy shafts is being discussed, and is influencing the practice of modern mill construction.

Fly-wheels on line.

Transmission of motion by belts.

In a system of transmission by belts only, it is of importance that both the belts and the pulleys, or

band wheels upon which they run, should be in the best possible condition.

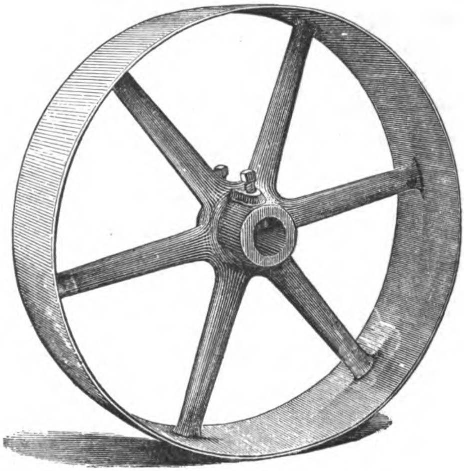
Leather belts.

The best belts used are of leather, kept in good condition by the judicious use of oil. Belts of leather are made of single thickness of leather for some purposes, and of two or more thicknesses for the endurance of heavier strains. In general, main driving belts are made double thickness, and belts for transmission of power to machines, with some exceptions, are made single thickness. The terms double and single belts have come to be applied to leather bands in the trade, while india-rubber belts, now quite extensively used, and often to advantage, have their grades indicated by one-ply, two-ply, three-ply, etc., as indicating their thickness. It is of the utmost importance, for considerations of economy in running, as well as first cost, that pulleys should be made as light as is consistent with strength. Pulleys that are to sustain the weight of double belts must be made heavier and stronger than those that are to sustain the weight of single belts; and the use to which the pulley is to be applied must influence its proportions. In the early practice of making cast iron pulleys it was believed necessary that the arms should be made something like the letter *S* on the plane of the pulley. The idea was that they would be less likely to break from shrinking strains in the casting. It is quite evident, however, that a straight arm, such as is shown in Fig. 101, representing a straight line from the centre to the circumference, will take the least metal; and we can state as a fact, after very long experience, that pulleys made with straight arms are the strongest, with equal proportions, provided proper precaution be taken in selecting the iron to be used in making and

India-rubber belts. Pulleys for double belts. Straight arm.

regulating the conditions of cooling. The straight-armed pulley can be made with the least possible

FIG. 101.



metal and the greatest possible strength for the metal. Its form is the best able to transmit the peculiar strains brought to bear upon it, and at the same time it is the most pleasing form to the eye. In machinery, as in nature, fitness to intended purposes has much to do with our ideas of beauty.

We make the arms oval, of such proportion as to present the least surface of resistance to the air in running, and as light as is consistent with strength. We are fitted with patterns varying in diameter by ¼ inch up to 12 inches diameter, by ½ inch up to 20 inches diameter, by 1 inch up to 30 inches diameter, and by 2 inches up to 72 inches diameter. Of these various sizes we make varying widths of face, the **Sizes of pulleys**

arms in all cases being proportioned to the work the pulley is expected to do. Thus, for single belts which do not shift upon the pulley we make the pulleys "high" or crowning in the centre of the face, and with rims and arms of adequate strength; if for a double belt, the rims and arms are made stronger in proportion. If for a shifting belt, as are the pulleys on line shaft, which lead on to fast and loose pulleys on the counters, the faces are made straight, and the arms are adapted to the belt intended to be used on the pulley. This may be thought to be a needless refinement; but it affects the cost. If such a system were not adopted, all pulleys would require to be made strong enough for the heaviest work, and those wishing them for light work would have to pay the price of the heaviest; whereas by our system we not only are enabled to sell pulleys at prices varying with their requirements, but such pulleys, when in place, do not contain any superfluous metal to weigh down the shaft and add to the cost of running it.

Single belts high.

Straight face.

Light pulleys.

We should in all cases know what kind of belt is to be used on the pulley; but we should also know the speed at which the pulley is to run, as we carefully balance all our pulleys to run without shaking at the required speed. Small pulleys are bored to a size that allows them to slide over the shaft loose and be held by set screws. We so arrange the boring and turning that the pulleys so held run true when fastened by the set screws. Pulleys over 36 inches diameter, 4 inches face, should in all cases be held by keys; if required to be a loose fit, with key and set screws combined. In this case the key seat is straight, not taper; the key must be let into the shaft, the pulley pushed over it, and held in place by the set screws.

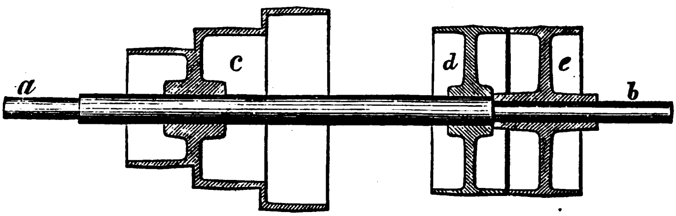
Pulleys held by set screws.

In case of large driving pulleys, such as those that receive the belt from engine, the fits should be made on the shaft with the same care as is used in putting on a plate coupling; *i.e.* when we are advised of the position on the shaft (as we should be in all cases) we leave a "fit" part of the shaft larger than the balance of the shaft, and bore the pulley so as to require forcing on with screw press. The advantage of holding the large pulley in this manner is so great that no consideration of false economy, or fear of trouble in getting the work put in place, should deter the user from having this part of the work carefully fitted. In the case of fast and loose pulleys on counter-shaft, we always make the hub of the loose pulley longer than the width of the face of the pulley, and we arrange the hubs of the fast pulley and loose pulley so that they shall meet and keep the edges of the rims apart a proper distance. We can make the loose and fast pulleys to fit the same sized shaft, but our preference is to neck down the counter-shaft at one end to journal size, and place the loose pulleys on this smaller part next to the hanger, so that the oil fed to the hanger will pass also into the hub of the

Loose pulleys

Necking down for loose pulleys.

Fig. 102.



loose pulley, and the box of hanger will hold the loose pulley in place. Fig. 102 shows this arrangement.

Counter hangers.

As counter hangers require no vertical adjustment to keep them in line, we make the box to swivel on a ball joint, in the same manner as in line hanger, but

FIG. 103.

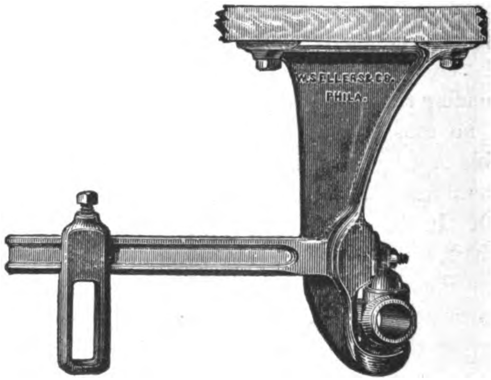


FIG. 104.

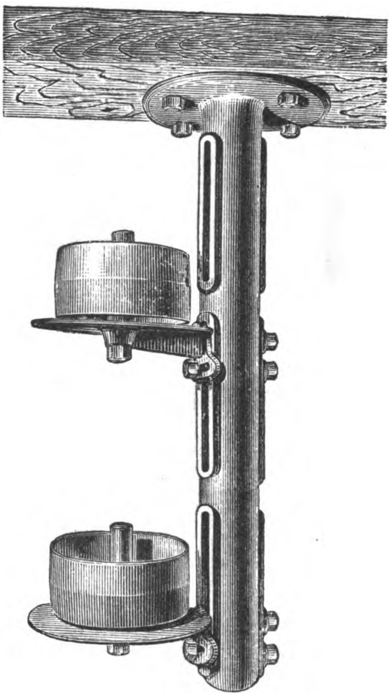
Belt-shifter arms.

held by a cap only, with a fixed oil dish under the box, and, when required, belt-shifter arms and guides for the belt-shifter rod, as shown in Figs. 103 and 104.

Turning corners with belts

In substituting belts for gear wheels in the transmission of motion, it must be borne in mind that all possible contingencies of position of shafts one to the other, whether parallel or at any angle, can be more readily met by belts and pulleys, even up to belts 24 inches wide, than with gearing, and in a much more

Fig. 105.

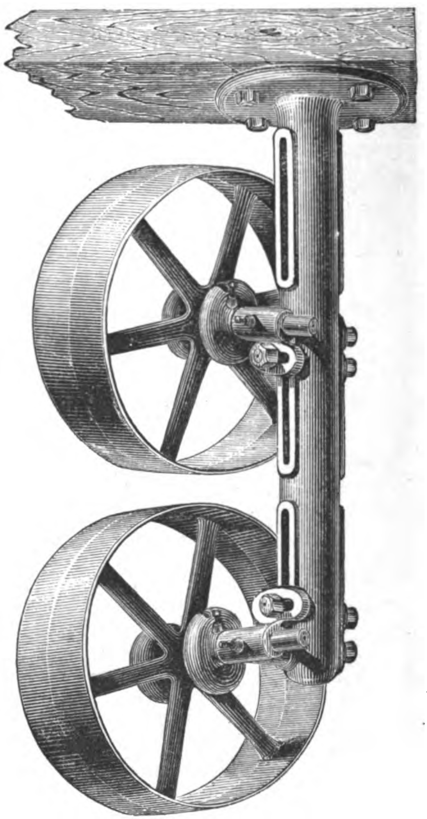


satisfactory manner. To meet some of the cases which most frequently occur, for belts of 10 inches and under we arrange "mule pulley stands" (Fig. 105) for

Mule pulleys.

the transmission of motion to shafts on the same plane or nearly so, and at any required angle to each other.

FIG. 106.



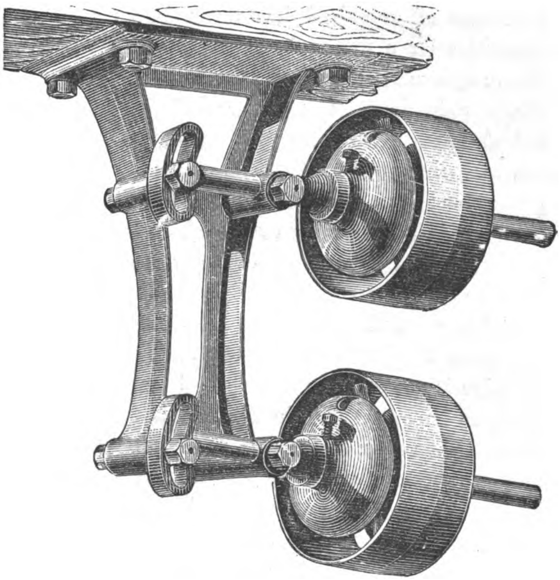
Large binder frame.

Where the same thing is to be accomplished with the shafts on very different planes, we furnish the "binder frame" (Fig. 106) for cases requiring from

4-inch to 10-inch belts; while for the transmission of power to machines at right angle to line, where the amount of power is not great, say for 3-inch belts, we furnish a smaller "binder frame" (Fig. 107,) admirably adapted to this purpose. This last is largely

Small binder frames.

FIG. 107.



used in transmitting from lines to spinning frames which set at right angles to the line: the fast and loose pulleys being on the machine, these frames take the place of counter-shafts.

Where special arrangements are required for the transmission of a large amount of power to shafts at any angle to each other, we have various devices

applicable to such cases that can be furnished. With us, all that pertains to mill gearing and shafting has been reduced to a systematic manufacture. To make a machine is one thing; to manufacture machines is quite another thing. Thus, one sewing machine may be made by itself at a cost more or less in proportion to the labor expended upon it. But the same machine, by means of organized labor, can be produced in quantities for a tenth of the cost of one machine. Hence systematized manufacture is needed to insure cheap productions. Our hanger and coupling would, indeed, have been expensive luxuries if simply made one at a time, with no special tools fitted to their production; but with such special tools, thorough organization of the labor employed, and the production of immense numbers of them, with all parts made to gauges, and interchangeable, the cost is less now than what the commonest rigid bearing hangers and plate coupling were made for formerly, and their adoption is now universal. Apart from systematized labor, an important item in first cost is weight of material. Not very many years ago, all shafting, and all pulleys, and everything relating to the machine for transmitting motion, were made and sold by the pound. Purchasers were attracted to the makers who charged the least per pound, and no very great care was taken to see that too many pounds did not go into the various parts of the machine. Shafts of a given size could not be made to weigh more or less by different makers; but much needless weight might be put into hangers, into couplings, and into pulleys, so that the price per pound really came to have no meaning, so far as total cost was concerned.

System of uniform gauge.

Shafting sold by the pound.

In 1856, feeling that this system of selling hangers,

pulleys, couplings, etc., by the pound, was not the proper way to dispose of such things, we determined on a radical change; we instituted an extensive series of experiments to demonstrate just how strong, and consequently how heavy, each article comprised under this head should be. We found that pulleys might be reduced in weight, and, by the employment of suitable machinery, be more perfectly made; so of hangers, and all that pertains to shafting, except the shafts. We then published a price list, offering to sell each item at some certain fixed price, dependent upon its own cost. The price list enables the purchaser to know beforehand just how much money will be required to obtain what he wants, and for strength and durability he must take the judgment of the makers. There was great opposition to this system from those who were still anxious to sell by the pound; but in time the manifest advantages of the plan caused its adoption by other makers.

Fixed scale of prices.

All conceivable wants of the trade are met by specially contrived devices, which can be made in quantities and kept in stock ready for sale. Hangers varying in size and "drop" (*i.e.* in distance from centre of shaft to the foot) are made from carefully designed patterns. Pulleys fitted for double or single belts, for wide or narrow belts, and made high or straight on the face, are all from patterns nicely adapted to the work each has to do. Last, but not least, all these things are made to standard gauges, so as to have their parts interchangeable. In regard to the sizes mentioned, in speaking of shafts, they are called always from the size of the bar iron from which they are made, and the term "shafting size" has come to have a significant meaning. All turned shafts are

Size of shafts

made from merchantable sizes of round bar iron, and in turning, one-sixteenth is taken off in diameter, so that what is called a 2-inch shaft is really only one and fifteen-sixteenths in diameter, and so of other sizes; they are all one-sixteenth less than their name implies; and the couplings, hangers, etc., are made to conform to these sizes.

Table for laying out shafting.

To aid in arranging the couplings in proper relation to the hangers, as also to furnish a ready method of determining the length of each shaft on a line, with a view to ordering the same, we have prepared a "table for laying out shafting," which we give facing this page. In this table will be found, in the columns at the right-hand side, the length of the boxes or bearings, and the length and diameter of our double cone-vice couplings. Examples are given, at head of table, of a line of shafts extended in both directions from the first or head shaft, and of a line extended in one direction only. The first example is of what is usually denominated a collared shaft coupled at both ends; the other, of a collared shaft coupled at one end only. Lines of shafting laid out according to this table will present each coupling the same distance from the end of the box nearest to it, regardless of the size of the shaft.

TABLE FOR LAYIN

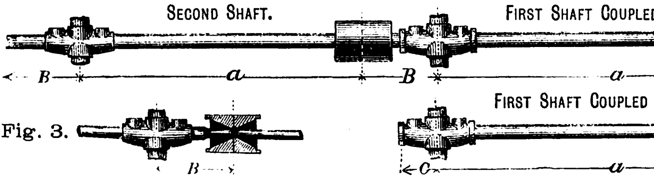
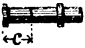


Fig. 3.

In Coupling a small shaft to a larger one, the Coupling is the size of the small one, the large shaft being turned down.
SEE FIGURE 3.

 C	Size of 2d Shaft.	1¾″	2″	2¼″	2½″	2¾″	3″	3¼″
		DISTANCE FROM CENTRE OF BEARING T SEE B, FIGURES 1						
Length of Collared End.	Size of 1st Shaft.							
4″	1¾″	9¾″						
4½″	2″	10¼″	11″					
5″	2¼″	10¾″	11½″	11¾″				
5⅝″	2½″	11¼″	12″	1′0¼″	1′0¾″			
6¼″	2¾″	11¾″	1′0½″	1′0¾″	1′1¼″	1′1⅝″		
6¾′	3″		1′1″	1′1¼″	1′1¾″	1′2⅛″	1′2⅝″	
7¼″	3¼″		1′1½″	1′1¾″	1′2¼″	1′2⅝″	1′3⅛″	1′3½
7⅞″	3½″		1′2″	1′2¼″	1′2¾″	1′3⅛″	1′3⅝″	1′4″
$8\frac{15}{16}$″	4″		1′3″	1′3¼″	1′3¾″	1′4⅛″	1′4⅝″	1′5″
10″	4½″			1′4¼″	1′4¾″	1′5⅛″	1′5⅝″	1′6″
11⅛″	5″				1′5¾″	1′6⅛″	1′6⅝″	1′7″
12⅛″	5½″					1′7⅛″	1′7⅝″	1′8″
13¼″	6″					1′8⅛″	1′8⅝″	1′9″

I
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table
Shaf
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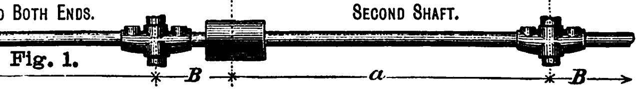
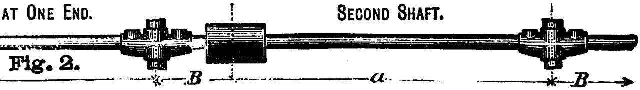
lengt
Fig.

G OUT SHAFTING.

) BOTH ENDS. SECOND SHAFT.



AT ONE END. SECOND SHAFT.



Make Bearings at equal distances from each other, when practicable, and always put Two Bearings on the First, which is the Collared Shaft.

SEE FIGURES 1 AND 2.

	3½"	4"	4½"	5"	5½"	6"

TO END OF SHAFT FOR COUPLING.

, 2 AND 3.

USE OF TABLE.

Look for size of first Shaft in left hand column, un-
he head of size of first Shaft, and in the top line of
, marked size of second Shaft, find the size of the
t to be coupled to it. The intersection gives the length
is added to the length A, or distance from centre to
e of Bearing, and in cases similar to Fig. 2, to the
h C, gives the length of the first Shaft, thus: as in
. B+A+B=Length. Fig. 2. C+A+B=Length.

"						
	1'4½"					
	1'5½"	1'6¼"				
	1'6½"	1'7¼"	1'8¼"			
	1'7½"	1'8¼"	1'9¼"	1'10⅛"		
	1'8½"	1'9¼"	1'10¼"	1'11⅛"	1'11½"	
	1'9½"	1'10¼"	1'11¼"	2'0⅛"	2'0½"	2'1¾"

Length of Bearing, or Box.	Patent Double Cone-Vice Coupling. Length.	Diam.
7"	6½"	4⅝"
8"	7⅝"	5⅜"
9"	8¼"	5⅞"
10"	9½"	$6\frac{9}{16}$"
11"	10"	7"
12"	11"	7¾"
13"	12"	8¼"
14"	13"	$9\frac{1}{16}$"
16"	14¼"	10"
18"	16"	11⅜"
20"	18"	$12\frac{9}{16}$"
22"	19"	13½"
24"	21"	14½"

PATENT INJECTORS FOR FEEDING BOILERS.

IT is not proposed in the following remarks on injectors or continuous boiler feeders to enter into any scientific explanations of the theory of their operations, but to give such practical information as will enable steam users to understand the conditions that should guide them in selecting from the various instruments made by us, and to enable them to use them to the best advantage.

False impression regarding the injector.

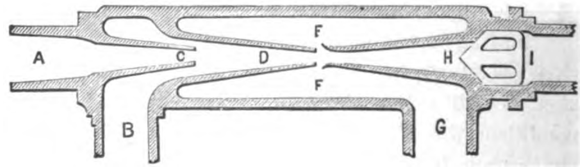
The impression made on most persons at the introduction of the Giffard injector, that its theory of operation was incomprehensible and its practical working involved nice adjustment of parts liable to be easily impaired, made users of the instrument distrustful until familiarity with it had given them confidence. Our construction of the instrument of such a form as to admit of its being readily opened for inspection, tended more than anything else, probably, to do away with this feeling; while, at the same time, its extended use has demonstrated the correctness of the statement of M. Ch. Combes, Inspector-General and Director of the *École des Mines*, who, speaking of the injector for feeding boilers, said, "It is without doubt the best of all those hitherto used for feeding boilers, and the best that can be employed, as it is also the most ingenious and simple, . . . and is theoretically perfect."

Opinion of M. Ch. Combes.

Simplest form of injector.

The injector in its simplest form (all details of construction being intentionally omitted) is shown in Fig. 108. It consists of a pipe *A* for the admission of steam, which, escaping through the nozzle *C* at a high velocity, is joined by water, which, flowing in through the pipe *B*, and passing around the end of nozzle *C*, mingles with and condenses the steam in the conical pipe

FIG. 108.



D, and is driven through the pipe *H* and check valve *I* into the boiler; excess of steam or water, from want of adjustment, escaping by the outlet *FF* and pipe *G*.

Names of parts of injector.

The parts shown are common to all forms of injectors, under various shapes and modifications, and have been named: *C*, receiving tube; *D*, combining tube; *H*, delivery tube; *I*, check valve; *FF*, overflow; and *G*, overflow nozzle. During the passage of the water from *D* to *H*, it is driven across the space *F*, and if too much water is being supplied to the steam, some water may escape at this point and flow out through the overflow nozzle *G*; while if there be too little water, air will be drawn in at *G* and carried into the boiler with the water.

An injector can be made substantially as shown, and its various parts so proportioned as to yield a good result with a given pressure of steam and a fixed quantity of water. Such an instrument is known as a "fixed nozzle injector," and its use will be presently explained.

Fixed nozzle injector.

It will give a constant feed of a given quantity at a given pressure of steam, but cannot be made to vary much in its quantity of delivery. To effect a variation of quantity of water fed, the position of the conical nozzles must be altered in their relation to one another. This alteration, which is an essential feature, was accomplished in the Giffard injector by a spindle in the steam nozzle to contract or enlarge the opening for the discharge of steam, and a movement of the nozzle *C* nearer to or farther from the combining tube *D*, so as to contract or enlarge the annular space between the tubes, to diminish or increase the water supply.

To effect a variation in amount of feed.

Giffard injector.

The Giffard injector was therefore an adjustable nozzle injector,—adjustable in both the water and steam supply within the instrument itself. With this instrument any change in steam supply required a corresponding change in the water supply, and if the proper relation between these parts was not maintained there was either a waste of water from the overflow or an indraught of air at this place. So that if after an adjustment of the parts to produce the best results the steam pressure of the boiler changed, the instrument would work badly until readjusted to the new condition. This led to the introduction of the self-adjusting injector, which is so arranged as to have no waste at the overflow; the steam being adjusted by hand, the instrument itself adjusts the water supply. Thus, when the injector is in operation, any change in boiler pressure makes a corresponding change in the water-flow to the combining tube, and as a result the steam is always combined with the exact quantity of water necessary to produce the best result, with neither waste nor indraught of air. This instrument, which will be described in the proper place, represents

Adjustable nozzle injector.

Proper relation of the parts must be kept up by hand adjustment.

Self-adjusting injector.

Adjusts its own water supply.

Self-adjusting instrument the highest type.

the highest type of the invention, and the one most advantageous to use. We are clearly of opinion that the best results can be obtained by the use of our self-adjusting injector in some of its forms or modes of setting; but, inasmuch as during our extended experience as makers of injectors we have designed various forms of instruments, we wish it clearly understood that we are prepared to furnish any of these styles that may be preferred by our customers, so that, to meet all cases of ordinary continuous boiler feed, we offer instruments varied in their arrangements to suit different circumstances. These we will describe in detail.

THE FIXED NOZZLE INJECTOR A

Can be adjusted, before being put in place, to any given pressure of steam; at that pressure will feed continuously at the maximum, and admits of a very limited variation of steam pressure while working. It will not lift or draw water from a lower level; is simple, and has no moving parts. It admits of being readily taken apart to clean if obstructed by sediment.

Will not lift water.

In this instrument there is a fixed receiving tube, the combining tube being adjustable when the instrument is apart. This adjustment permits the instrument to be set at some given pressure of steam, from 5 to 150 pounds boiler pressure, but will work only at or near to the steam pressure at which it has been set. It can be used to advantage in cases where the steam pressure and required feed do not vary much. On locomotives it is applicable as an auxiliary, when the instrument can be located below the level of the bottom of the water tank, so that the water can flow to it. We

Adjustment of combining tube.

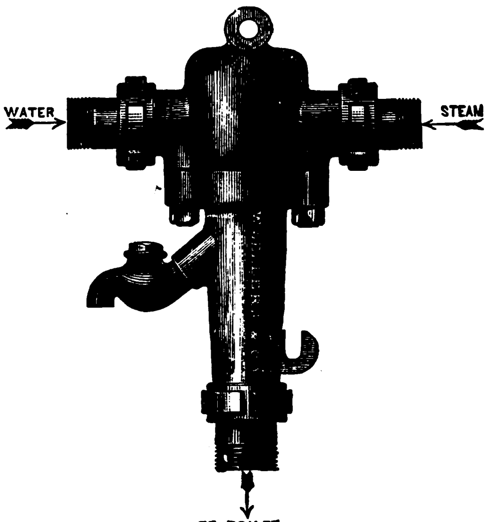
Has no great range.

Can be used as an auxiliary on locomotives

place a check valve opening outward on the overflow nozzle. If the instrument is placed horizontally, the valve of check must be turned so as to be perpendicular; otherwise it makes no difference in what position the instrument is located. Its maximum delivery is not

Location of instrument.

FIG. 109.



so great as the self-adjusting injector. The following table gives the number of cubic feet of water that can be fed by each size of instrument at any given pressure:

Table of Capacities for Fixed Nozzle Injectors.

SIZE.	Size of Pipe for Connections.	PRESSURE OF STEAM, IN POUNDS.						
		10	20	30	40	50	60	70
		CUBIC FEET OF WATER DISCHARGED PER HOUR.						
No. 2	½ in.	5.050	6.304	7 344	8.254	9.073	9.824	10.522
" 3	¾ "	11.465	14.30	16.658	18.723	20.581	22.284	23.867
" 4	1 "	20.50	25.568	29.786	33.476	36.799	39.845	42.674
" 5	1¼ "	32.175	40.129	46.748	52.553	57.754	62.536	66.977
" 6	1¼ "	46.500	57.997	67.564	75.935	83.471	90.381	96.799
" 7	1½ "	50.431	79.184	92.246	103.67	113.96	123.4	132.16
" 8	2 "	83.145	103.7	120.8	135.78	149.25	161.6	173.08
" 9	2 "	105.48	131.55	153.26	172.24	189.34	205 01	219.57
" 10	2 "	130.5	162.75	189.6	213.1	234.25	253.64	271.65
" 12	2½ "	188.6	235.23	274.03	307.98	338.54	366.57	392.6
" 14	2½ "	257.5	321.15	374.13	420.49	462.23	500.49	536.02
" 16	3 "	337.22	420.59	489.97	550.68	605.34	655.44	701.98
" 18	3 "	427.8	533.56	621.59	698.6	767.94	831.5	890.54
" 20	3½ "	529.15	659.6	768.83	864.09	949.84	1028.1	1101.5

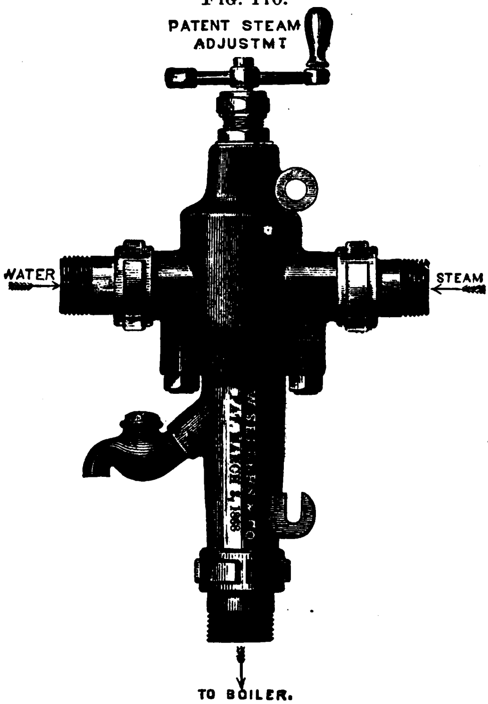
SIZE.	PRESSURE OF STEAM, IN POUNDS.							
	80	90	100	110	120	130	140	150
	CUBIC FEET OF WATER DISCHARGED PER HOUR.							
No. 2	11.436	11.794	12.381	12.941	13.479	13.996	14.493	14.941
" 3	25.357	26.752	28.084	29.355	30.574	31.746	32.876	33.89
" 4	45.328	47.834	50.215	52.488	54.667	56.762	58.783	60 596
" 5	71.140	75.074	78.811	82.379	85.799	89.088	92.259	95.106
" 6	102.82	108.5	113.9	119.06	124.0	128.76	133.34	137.45
" 7	140.38	148.14	155.52	162.55	169.3	175.79	182.05	187.67
" 8	183.84	194.0	203.66	212.88	221.72	230.22	238.42	245 77
" 9	233.22	246.12	258.37	270.06	281 28	292.05	302.45	312.05
" 10	288.53	304.49	319.64	334.11	347.99	361.32	374.18	385.73
" 12	417.01	440.07	461.97	482.89	502.93	522.21	540.8	557.49
" 14	569.35	600.83	630.74	659.29	686.66	712.98	738.36	761.14
" 16	745.63	786.85	826.02	863.42	899.26	933.73	966.97	996.8
" 18	945.91	998·21	1047.9	1095.4	1140.8	1184.5	1226.7	1264.6
" 20	1170.0	1234.7	1296.1	1354.8	1411.1	1465.1	1517.3	1564.1

Has no minimum.

FIXED NOZZLE INJECTOR B WITH PATENT SPINDLE FOR STEAM ADJUSTMENT.

This instrument is the same in every respect as the fixed nozzle injector A, except the steam adjustment; the steam spindle adds to it the power to lift water, **Will lift water.** say a distance of 8 feet for the smallest instruments,

FIG. 110.



and more for larger ones: in other respects its operation is the same as the fixed nozzle injector A. Its **Location of instrument** use on a locomotive would be the same; and it can be

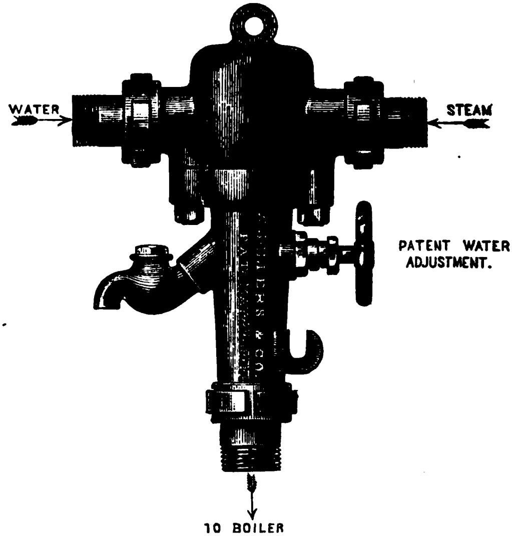
placed higher up on the engine, lifting the water from the tank. It has no minimum. (For table of capacities, see page 226.)

PATENT ADJUSTABLE WATER NOZZLE INJECTOR C.

Can be adjusted while running.

Capable of being adjusted to suit pressure of steam while running, with very limited range in quantity of water injected at any given pressure of steam. This possibility of adjustment of the combining tube by means of the handle marked "water adjustment" in the cut, Fig. 111, gives the instrument a decided ad-

Fig. 111.



vantage over either the fixed nozzle injectors *A* or *B*, inasmuch as it may be attached to any boiler before the pressure upon the boiler is ascertained,

and upon variation of pressure in boiler it can be readily adjusted. It, in common with the two previously described instruments, works well only at the maximum delivery. (For table of capacities, see page 226.) It can be readily taken apart to clean, and will work from 5 to 150 pounds pressure. **Can be readily cleaned.**

PATENT ADJUSTABLE INJECTOR D,

With steam and water adjustment, provided for as in the original Giffard injector, but very much simplified **Simplified.** in its details by dispensing with packing and increasing its efficiency to lift and force water. This instrument has the full range of maximum and minimum **Has full range.** delivery, but requires to be adjusted by hand, both in water and steam. It will lift water a distance of 8 **Will lift water.** feet with smallest sizes, and more with larger ones. Will work from 5 pounds to 150 pounds boiler pressure. Is readily taken apart to be cleaned. It can be placed in any convenient position on a locomotive.

To illustrate this form of injector we give two cuts, on pages 230 and 231, showing the outside and section of the instrument.

We also make the old style injectors, with a hand **Old style.** wheel to adjust the water supply, and can repair all the various instruments made by us with dispatch, or can send such parts as may be needed to make repairs by the users when we are informed of size and style of instrument.

FIG. 112.

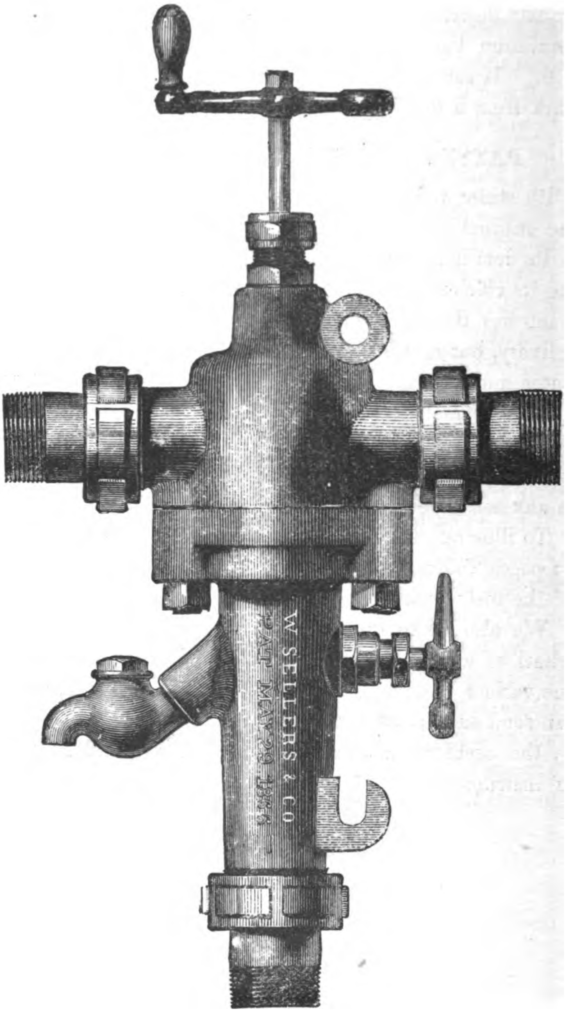


FIG. 113.

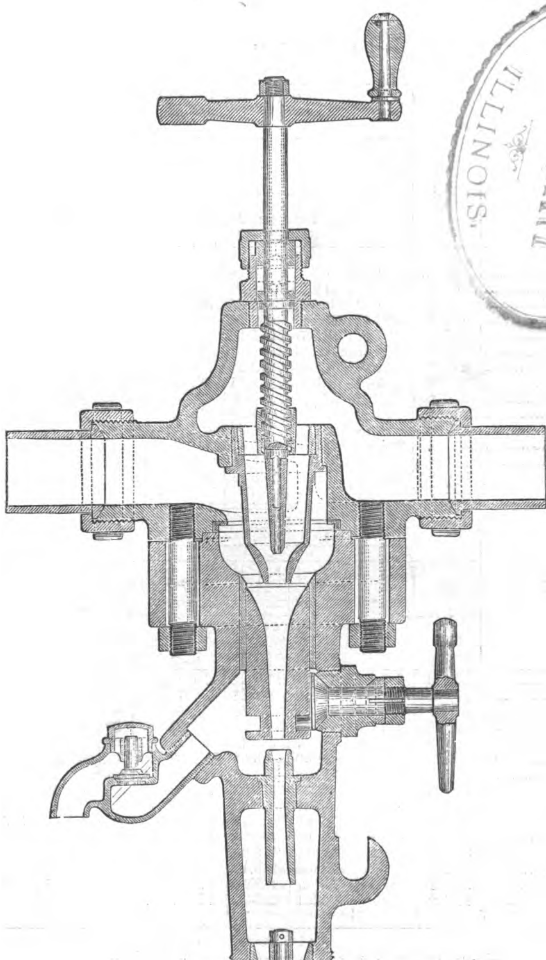


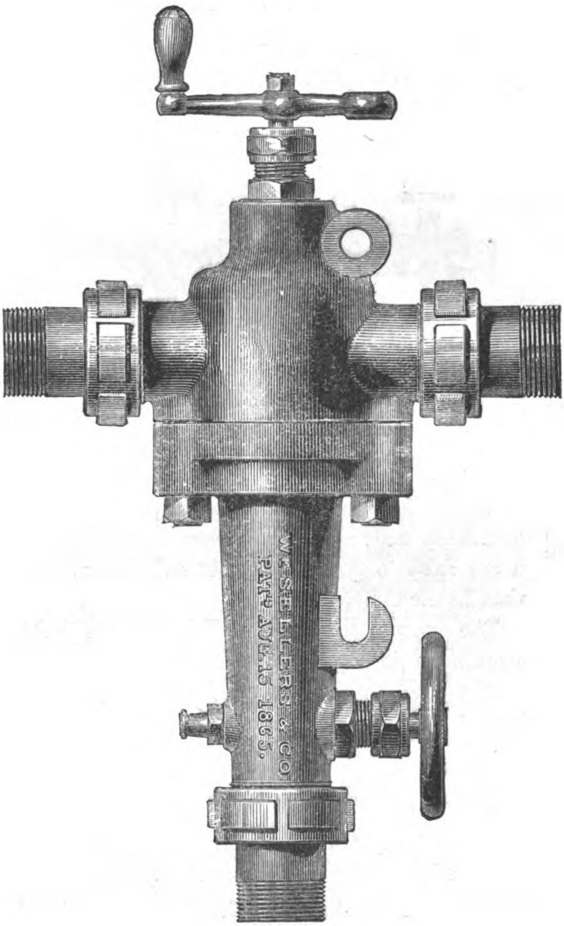
Table of Maximum Capacities of Patent Adjustable Nozzle Injectors.

SIZE.	Size of Pipe for Connections.	PRESSURE OF STEAM, IN POUNDS. CUBIC FEET OF WATER DISCHARGED PER HOUR.						
		10	20	30	40	50	60	70
No. 2	½ in.	5.050	6.304	7.344	8.254	9.073	9.824	10.522
" 3	¾ "	11.,65	14.30	16.658	18.723	20.581	22.284	23.867
" 4	1 "	20.50	25.568	29.786	33.476	36.799	39.845	42.674
" 5	1¼ "	32.175	40.129	46.748	52.553	57.754	62.536	66.977
" 6	1¼ "	46.500	57.997	67.564	75.935	83.471	90.381	96.799
" 7	1½ "	50.431	79.184	92.246	103.67	113.96	123.4	132.16
" 8	2 "	83.145	103.7	120.8	135.78	149.25	161.6	173.08
" 9	2 "	105.48	131.55	153.26	172.24	189.34	205.01	219.57
" 10	2 "	130.5	162.75	189.6	213.1	234.25	253.64	271.65
" 12	2½ "	188.6	235.23	274.03	307.98	338.54	366.57	392.6
" 14	2½ "	257.5	321.15	374.13	420.49	462.23	500.49	536.02
" 16	3 "	337.22	420.59	489.97	550.68	605.34	655.44	701.98
" 18	3 "	427.8	533.56	621.59	698.6	767.94	831.5	890.54
" 20	3½ "	529.15	659.6	768.83	864.09	949.84	1028.1	1101.5

SIZE.	PRESSURE OF STEAM, IN POUNDS. CUBIC FEET OF WATER DISCHARGED PER HOUR.							
	80	90	100	110	120	130	140	150
No. 2	11.436	11.794	12.381	12.941	13.479	13.996	14.493	14.941
" 3	25.357	26.752	28.084	29.355	30.574	31.746	32.876	33.89
" 4	45.328	47.834	50.215	52.488	54.667	56.762	58.783	60 596
" 5	71.140	75.074	78.811	82.379	85.799	89.088	92.259	95.106
" 6	102.82	108.5	113.9	119.06	124.0	128.76	133.34	137.45
" 7	140.38	148.14	155.52	162.55	169.3	175.79	182.05	187.67
" 8	183.84	194.0	203.66	212.88	221.72	230.22	238.42	245.77
" 9	233.22	246.12	258.37	270.06	281 28	292.05	302.45	312.05
" 10	288.53	304.49	319.64	334.11	347.99	361.32	374.18	385.73
" 12	417.01	440.07	461.97	482.89	502.93	522.21	540.8	557.49
" 14	569.35	600.83	630.74	659.29	686.66	712.98	738.36	761.14
" 16	745.63	786.85	826.02	863.42	899.26	933.73	966.97	996.8
" 18	945.91	998·21	1047.9	1095.4	1140.8	1184.5	1226.7	1264.6
" 20	1170.0	1234.7	1296.1	1354.8	1411.1	1465.1	1517.3	1564.1

Minimum capacities 60 per centum of the maximum.

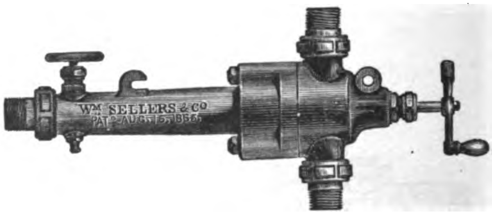
Fig. 114.



PATENT SELF-ADJUSTING INJECTOR

Will work with from 5 pounds up to 150 pounds boiler pressure. Will perform a higher "duty" than any

FIG. 115.



other form of injector. Is simple and easily kept in repair; starts readily, and will not stop or knock off from irregularities in flow of steam. The superior advantages of this instrument warrant our dwelling on its details of construction, more particularly as we

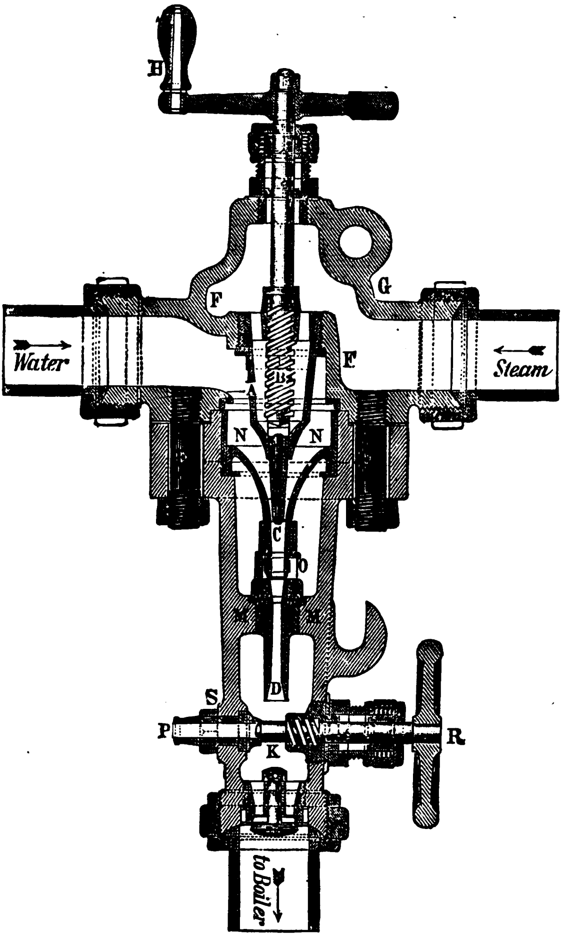
Improvements increasing its efficiency. have lately made important improvements in it, making it less liable to stop from dirt or sedimentary deposits than heretofore.

The annexed sectional cut, Fig. 116, shows the instrument in its most improved form.

Outer shell. The outer shell, or case, consists of two parts, united by bolts, *EE*. The part *GG* is provided with two inlets, the one for steam, the other for water, as shown in the cut, the two being separated by the plate, *FF*, in the centre of which is attached a nozzle, called the receiving tube, *A*, for the steam jet. The amount of steam which may be discharged by this nozzle is regulated by the tapered plug, which is operated by

Steam spindle. the screw, *B*, and exterior handle, *H*. The interior of the case, *MM*, is bored out for a short distance, and fitted with a lining of brass, turned out to receive the

Fig. 116.



piston, *NN*, which plays freely along it. This piston forms the upper or receiving end of the converging pipe, *C*, called the combining tube. The lower end of this tube is exteriorly cylindrical, and slides in a guide at the upper end of the delivery tube, *D*, which is stationary, being screwed into the outer shell at *MM*.

Combining tube.

Guide for combining tube.

Beyond this point, again, a small stop valve, *PR*, affords, when open, a lateral outlet to the tube, *K*; and beyond this, again, a check valve is placed between the instrument and the boiler.

Waste valve.

To put this apparatus in operation, the stop valve, *PR*, is opened, and the steam plug, *B*, is closed; a little steam being let in, will escape through the small hole in the end of the steam plug, producing a vacuum, when the water is drawn up and forced through *C* and *D* into the pipe, *K*, from which it escapes by *P*. The plug, *B*, is then drawn back, so increasing the supply of steam, until the stop valve, *R*, can be closed, without causing the injector to cease working. This ceasing to work will be indicated by an escape of steam from the water-supply pipe. The action which is taking place in the apparatus, when thus in operation, may be briefly described as follows:

Mode of operation.

The steam passing into *C* is condensed by the water there combining with it from the water supply, and the concentrated jet is then driven through the delivery tube, *D*, into the pipe, *K*, from which, by raising the check valve beyond, it passes into the boiler.

Self-regulation.

If now the water supply is, or becomes, too great, a portion of water escapes by the opening, *O*, in the upper part of the delivery tube, and, accumulating in the surrounding chamber, forces back the piston, *NN*, which, of course, carries with it the tube, *C*, etc., thus diminishing the annular space through which the

water enters the combining tube, and so limiting its supply. If, on the other hand, the supply of water is not sufficient, the velocity of the steam jet will be increased, and a partial vacuum will be produced in the chamber, and the piston, *NN*, will consequently be brought downward, thus opening the space for water supply, and correcting the defect.

We thus see that the instrument is self-regulating, and will adapt itself to changed conditions of pressure, so as always to develop a maximum result proportioned to the quantity of steam used.

There are, besides this general principle and action, several other points claiming notice in this form of the instrument.

Size of waste pipe.

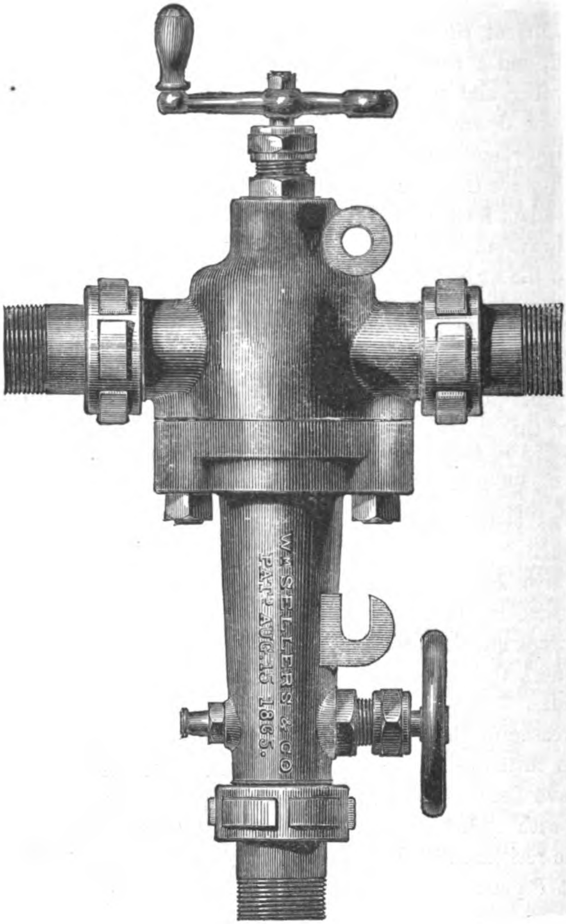
Thus, the waste pipe, *P*, must be of sufficient size to allow the smallest quantity of water which the injector will feed when in action, to pass through the pipe, *D*, under a pressure less than that in the boiler; for if this is not the case it will be impossible to start the instrument, as the jet would break so soon as the valve, *PR*, is closed.

The same result would follow if a pipe of some length were attached to the outlet, *P*, as this pipe would check the discharge by the frictional resistance of its sides.

Need of velocity of jet.

The reason of this is, that before the injector can begin to introduce water into the boiler, a stream must have been established, filling the pipe, *D*, and moving with sufficient velocity to enable it to overcome the resistance of the boiler. It is clear that the outlet at *P* must be able to deliver this stream freely, or such a pressure would be produced in the space, *K*, as would prevent the stream in *D* from acquiring the necessary velocity.

Fig. 117.



It is therefore evident that in any case where the waste is to be carried away by a pipe connected with *P*, this pipe must be of sufficient diameter to avoid such resistance as has been noticed. Practical experience has shown that, for a pipe of moderate length, a diameter at least twice that of the outlet, *P*, is requisite.

Centre hole in steam spindle.

It will be observed, also, that the conical plug, *B*, for regulating the steam supply, has a narrow passage bored along its axis, which communicates, by transverse openings, with the steam space around it.

By this means, when the plug, *B*, is forced all the way down, so as to close the outlet, *A*, a small jet of steam will pass by the opening in the plug, and will exert a much greater lifting force to raise water from the supply into the combining tube, *C*, than will be produced by a jet of steam through the annular space between the plug, *B*, and nozzle, *A*.

The reason it aids in lifting water.

The reason of this is, in part, as follows: To produce this lifting effect, which is quite dissimilar from that of the injector in its operation connected with the introduction of water into the boiler, and is more nearly allied to the action of the exhaust in producing a draft in the smoke-stack of a locomotive; the effect depends chiefly on the free expansion and high velocity of the steam jet at the moment it escapes from the nozzle, *A* (or the centre of plug, *B*), and upon the existence of an outlet beyond, *C*, not only sufficient to allow this expanded steam jet to pass freely, but also to give an exit to the air carried with it by friction.

Now, in all these respects, the annular jet between the plug, *B*, and nozzle, *A*, is at great disadvantage, as compared with the orifice in the centre of plug, *B*.

Thus the friction is immensely greater in the an-

nular jet, thereby reducing the velocity, especially if this jet is but slightly open; while, on the other hand, if more space is given in the annular jet, the amount of steam discharged will be more than can pass freely by the nozzle, *C*, thus rather tending to produce a back pressure than a vacuum, in *C* and the water-supply pipe. In fact, it is found that where, with the old arrangement, an injector is able to raise its feed (water) from 2 to 6 feet, with this modification it will lift its supply from 10 to 18 feet, depending upon the size of the instrument. In this connection it is proper to call attention to the necessity for excluding air from the water-supply pipes; any leak of this kind will not only impair the vacuum, but also, as air does not change its form or lose its elasticity when in contact with water, its presence in the steam jet will diminish the density of the jet and impair its ability to penetrate the boiler.

Height to which it will lift water.

The exterior appearance of this instrument is shown in Fig. 117.

The adjustment of the water supply to suit the steam pressure and steam supply also is effected, as has been seen, by the motion of the combining tube, *C*, towards the delivery tube, *A*, to decrease the water supply, and away from it to increase the water supply. This motion is effected by the piston, *NN*, which, except when moving, is in equilibrium so far as pressure on either side of it is concerned; so also with the guide at the lower end of the combining tube: this is steadied by sliding in a prolongation of the delivery tube, *D*, above the point of overflow, *O*. Accuracy of fit in these parts is not needed, as they are not in any case subjected to boiler pressure. The combining tube should play freely up and down in the case, and

Combining tube is not subjected to boiler pressure.

Need not be a close fit.

Should play freely in the chamber.

is held rigidly in place when working by the operation of the jet, and so long as it can move freely it will continue to act. We have said that the patent self-adjusting injector is at all times working to the best advantage (see page 223), throwing all the water possible with any given quantity and pressure of steam. This form of injector is so much more efficient than any other, that the maximum quantity any one size will deliver is as much as the next larger size of any of the old styles of injectors, as will be seen by comparing the table of maximum capacities of self-adjusting injectors, given on the next page, with that for the fixed nozzle and adjustable nozzle injectors, given on page 226. This must be taken into consideration in comparing the cost of the different kinds of injectors.

Is always working to the best advantage.

Comparison of quantity.

The greater capacity should be considered.

Referring to the notes at the foot of the respective tables, that the minimum capacity of the self-adjusting injector is 50 per cent. of the tabular capacity (which shows the maximum delivery), while with the fixed nozzle and adjustable nozzle injectors the minimum is not so low, being about 60 per cent. of the maximum, it will be readily seen that the self-adjusting injector to a higher maximum than any other form of injector adds an increased range.

Some recent changes in this instrument enable it to take much hotter water than is indicated on page 243. Actual trials give:

Temperature of feed water before it enters injector.	138°	135°	130°	130°	132°	133°	127°	124°
Pressure of steam in pounds per square inch.	20	40	60	80	100	120	140	150

Table of Maximum Capacities of Patent Self-Adjusting Injectors.

SIZE.	Size of Pipe for Connections.	PRESSURE OF STEAM, IN POUNDS. CUBIC FEET OF WATER DISCHARGED PER HOUR.						
		10	20	30	40	50	60	70
No. 2	½ in.	8.3	9.	9.7	10.4	11.1	11.8	12.5
" 3	¾ "	19.27	21.04	22.81	24.58	26.35	28.12	29.89
" 4	1 "	36.66	39.6	42.74	45.88	49.02	52.16	55.3
" 5	1¼ "	57.58	62.5	67.42	72.34	77.26	82.18	87.1
" 6	1¼ "	83.48	90.6	97.72	104.84	111.97	119.09	126.21
" 7	1½ "	114.03	123.75	133.48	143.2	152.93	162.65	172.38
" 8	2 "	149.2	162.	174.8	187.6	200.4	213.2	226.
" 9	2 "	189.2	205.35	221.51	237.66	253.82	269.97	286.13
" 10	2 "	233.84	253.8	273.76	293.72	313.68	333.64	353.61
" 12	2½ "	337.2	366.	394.8	423.6	452.4	481.2	510.
" 14	2½ "	451.49	491.45	531.41	571.36	611.32	651.27	691.23
" 16	3 "	600.32	651.6	702.88	784.16	805.44	856.72	908.
" 18	3 "	760.07	825.	889.93	954.86	1019.78	1084.71	1149.64
" 20	3½ "	938.84	1019.	1099.16	1179.32	1259.48	1339.64	1419.8

SIZE.	PRESSURE OF STEAM, IN POUNDS. CUBIC FEET OF WATER DISCHARGED PER HOUR.							
	80	90	100	110	120	130	140	150
No. 2	13.2	13.9	14.6	15.3	16.	16.7	17.4	18.1
" 3	31.66	33.43	35.2	36.97	38.75	40.53	42.31	44.09
" 4	58.44	61.58	64.72	67.86	71.	74.14	77.28	80.42
" 5	92.02	96.94	101.86	106.78	111.7	116.62	121.54	126.46
" 6	133.33	140.45	147.57	154.7	161.82	168.94	176.06	183.18
" 7	182.1	191.83	201.55	211.28	221.	230.73	240.46	250.19
" 8	238.8	251.6	264.4	277.2	290.	302.8	315.6	328.4
" 9	302.28	318.44	334.59	350.75	366.9	383.07	399.23	415.39
" 10	373.57	393.53	413.49	433.45	453.41	473.37	493.33	513.29
" 12	538.8	567.6	596.4	625.2	654.	682.8	711.6	740.4
" 14	731.18	771.14	811.09	851.05	891.	930.97	970.93	1010.89
" 16	959.28	1010.56	1061.84	1113.12	1164.4	1215.68	1266.96	1318.24
" 18	1214.57	1279.5	1344.42	1409.35	1474.28	1539.21	1604.14	1669.67
" 20	1499.96	1580.12	1660.28	1740.44	1820.6	1900.76	1980.92	2061.08

The minimum capacity 50 per centum of the maximum.

Nominal size of injector.

The numerical size of any injector is the diameter of the smallest part of the delivery tube expressed in millimetres. Thus, in a No. 2 injector the water is driven through an opening 2 millimetres in diameter, while in a No. 10 it passes through a hole 10 millimetres in diameter. The quantity of water that can be made to pass through this opening depends upon two conditions: the pressure of the steam, and the temperature of the water before it enters the instrument. The colder the water, the higher pressure of steam may be used to inject it. The hotter the water before it enters the injector, the lower must be the pressure of the steam. Thus, an instrument that with water at 70° Fahrenheit will *only* work up to 150 pounds of boiler pressure, will not work at that pressure if the water used be more than 70°. So that if hot water is to be used with any injector, it must be remembered that low steam only can be used in the following proportions, unless the proportions of the tubes be correspondingly changed:

Conditions which control the amount of feed.

Cold water better than hot.

Low steam only with hot water

Temperature of feed water before it enters injector............ ...	148°	138°	130°	124°	120°	110°	90°
Pressure of steam, in pounds, per square inch...................... ...	10	20	30	40	50	100	120

To determine size of instrument required

To determine the size of instrument needed for any particular case, a knowledge of the number of cubic feet of water required per hour will enable an instrument to be selected, by referring to the table of capacities for any special kind of instrument. When horse-power is known, the quantity of water may be approximately assumed by considering each horse-power to require one cubic foot of water per hour. But if the steam is used expansively to any great extent, as

Horse-powers and water required.

in some of the best modern engines, the quantity of water per horse-power might be reduced say 33 per cent. But in no case should the injector selected be larger than will give at maximum the number of cubic feet of water corresponding with the number of horse-power, inasmuch as the range of the instruments is limited to from 50 to 60 per cent. of the maximum capacity; and if too large an instrument is selected, the minimum may sometimes be too great for the wants of the boiler, requiring frequent stoppages to prevent flooding; which, apart from the trouble involved, is not so economical as a constant and regular feed equal to the drain on the boiler.

Too large an instrument objectionable.

Approximate horse-power of boiler.

To approximate the horse-power of any boiler, the following rules are useful. When area of grate surface is known: Area of grate in square feet $\times$ 1.6 = horse-power. In case of plain cylinder boilers, if the heating surface of boiler be known in square feet, divide by 10 for horse-power. In case of flue boilers, divide heating surface by 12; and with multitubular boilers, divide by 15 for the number of horse-powers.

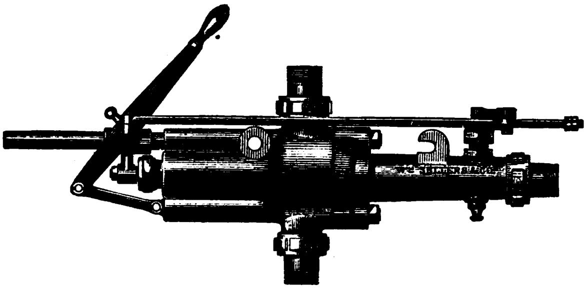
Grate area.

Fire surface.

The use of injectors on locomotives on many roads in this country has been limited to its attachment as an adjunct, to be used for filling the boilers when the pumps are not running, or when standing. In Europe, the injector has come to be the universal boiler feeder on locomotives, to the exclusion of the pump. The conditions which obtain abroad in locomotive practice do not differ essentially from our own, but the use or non-use of the instrument in place of pumps seems rather to depend upon the supervising officers than upon the runners, as in America, on some leading roads, when the use of the injector in running has been insisted on by the officers, it has come to be the

Practice abroad.

Fig. 118.



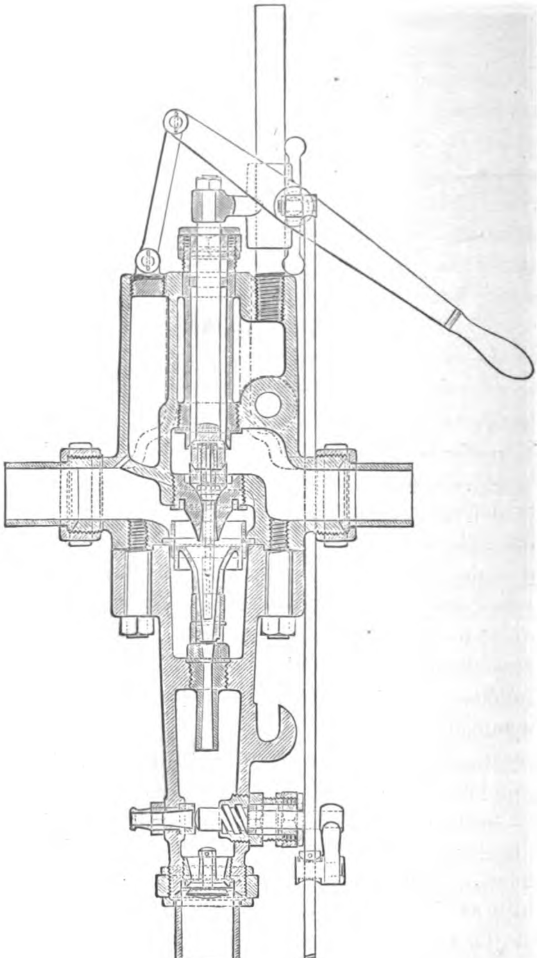
favorite method of feeding, and its use has been found to be more economical than the pump.

Objection is sometimes made to the use of the injector on locomotives on the ground that various parts have to be moved or adjusted to accommodate the operation of the instrument and to adjust it to use. To meet this objection we are making a modified form of our self-adjusting injector, arranged with special reference to locomotive practice. We figure this instrument on pages 245 and 246, Fig. 118 showing the exterior form of the instrument, and Fig. 119 a section of it. This new form of injector may be placed in any convenient position in the "cab." It will lift water with ease and certainty,—even when the pipes from the tender to the injector have been heated by the passage of steam. It is started, stopped, or regulated as to capacity by the one working lever, which renders its use as simple

Objections.

Position on engine.

Fig. 119.



as the least complicated form of pump attachment, and is much more certain in its action.

It is of the utmost importance that care be taken in setting all kinds of injectors by those who attach them to the boilers; and there are some particulars that may be mentioned as holding in common with all kinds of injectors. Among these may be noted:

Rules for setting.

FIRST. All pipes, whether steam, water-supply, or delivery, must be of the same internal diameter as the hole in the corresponding branch of each injector, and as short and straight as practicable.

Size of pipes.

SECOND. When floating particles of wood or other matter are liable to be in the supply water, place a wire screen over the receiving end of water-supply pipe, taking care to have the meshes as small as the smallest opening in the delivery tube, and the total area of meshes much greater than the area of water-supply pipe, to compensate for the closing of some of them by deposit.

Screen over water-supply pipe.

THIRD. The steam should be taken from the highest part of the boiler, to avoid priming, but should not be attached to the steam pipe leading to an engine unless this pipe is large: sudden variations in pressure may break the jet in the old styles of injectors, and would produce a constant movement of the piston in the self-adjusting.

Dry steam should be used.

FOURTH. When any injector capable of raising water is set so as to lift the water, care must be taken to have the pipes very tight, so as not to draw air; and it is of importance that in any arrangement of instrument the water supply should be unmixed with air, which will cause a sputtering sound, and is liable to break the jet.

Lifting water.

Must not draw air.

FIFTH. If the water is not lifted by the injector,

Injector fed from hydrant.

but flows to it from a tank or hydrant, there should be a cock in the water-supply pipe.

Cocks needed.

SIXTH. There must always be a stop valve or cock in the steam pipe between the steam space in boiler and injector, and a check valve between the water space of boiler and the injector. In addition to the above, certain precautions must be taken in setting the patent self-adjusting injector:

FIRST. There must be in the water-supply pipe an alarm check valve, with waste check attached, as shown in Plates II. and III.

Water regulating valve.

SECOND. When fed with water under pressure, ANY CONSIDERABLE PRESSURE IN THE WATER-SUPPLY PIPE MUST BE AVOIDED. We supply a water regulating stop valve, to be used when the water pressure in the supply pipe is too great.

See that pipes are all clear.

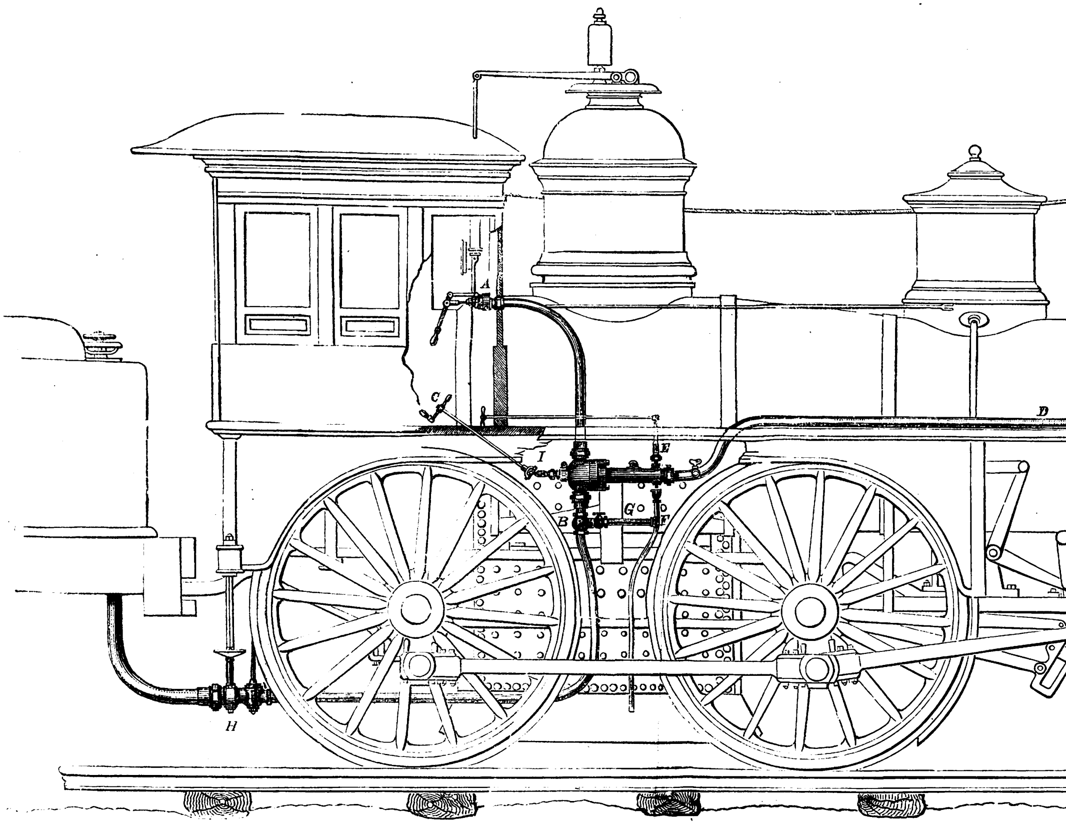
After all the pipes are properly connected to the injector and boiler, and before admitting steam to the injector, it should be disconnected again from the pipes at the three union joints, and the steam and water should be allowed to flow through the pipes, to remove any red lead, or scale and other solids, from the interior of the pipes. This precaution will avoid trouble at first starting, which otherwise is liable to occur.

Extra attachments.

To facilitate the efficient use of the instrument, we have arranged special attachments, such as starting valves and the like, for the two distinct uses to which these instruments are put, viz., to locomotives and to stationary boilers. Plate I. shows one method of attaching the injector to locomotives.

On locomotives above the tank.

It is not imperative, nor even important, that the injector should be placed upon the locomotive just as it is represented in the cut; but it is all-important that



POSITION OF INJECTOR AND ACC

A. *Steam Valve.*

B. *Check Valve in the Water Supply.*

C. *Regulating Handle.*

D. *Delivery Pipe to Check Valve on Boiler.*

E. *Escape or Waste Valve.*

F. *Waste Pipe at least twice the diam. of Escape Opening*

G. *Alarm Check and Pipe to Waste Pipe.*

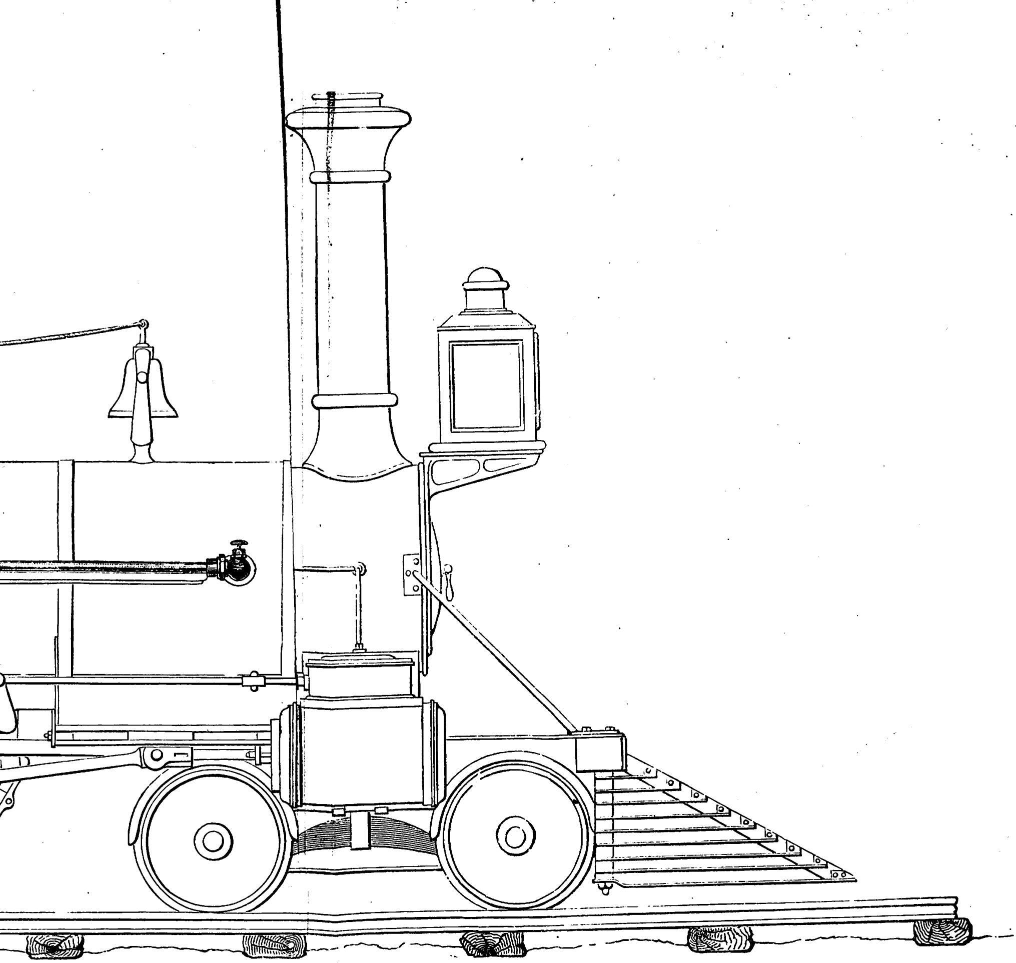
H. *Drip Cock in Feed Pipe.*

I. *Universal Joint.*

TO START IN

1st. Screw down Handle C. *2d. Open*
Valve A *a little, until water flows fro*
A *wide. Screw out Handle* C, *until t*
not cause any discharge from Alarm
screwing out to increase delivery, and i

N. B.—*A failure to work will alw*
steam and water from Alarm Check
Handle C *is too far down. Mark this*



CESSORIES ON A LOCOMOTIVE.

NJECTOR:

Waste Valve E. *3d. Open Steam*
m Waste Valve E; *then open Valve*
the closing of Waste Valve E *will*
Check G. *Regulate by Handle* C,
n to diminish it.

ays be indicated by a discharge of
G, *and will take place whenever*
point.

To use the instrument as a Heater for Tank:

Close the Waste Valve E *and admit the steam from Steam Valve* A. *In this case a small cock will be required on Waste Pipe* G *which must be closed when heating feed water. After using the Injector for this purpose, the hot water in Feed Pipe must be drawn off through the Drip Cock* H *before the Injector can be used to feed the boiler*

it should be placed so that its alarm must attract attention, and that the operator can manipulate it without moving from his ordinary position or taking his eye from the road; when these points can be secured; and the injector can be placed low enough to permit the water to flow through it, air will be excluded from the water supply, and an accidental supply of hot water can be readily discharged by flowing it through the waste valve, E; but these advantages should never be sought by sacrificing those referred to.

On locomotives below the tank.

Some locomotive builders place the instrument below the lowest water level in tank; and for convenience of manipulation in such cases we furnish, when desired, a universal joint, to enable the extension rod from steam spindle to be carried to a convenient place in the cab.

It is of the utmost importance that the appliances needed to work the injector, such as starting cock and the various other valves, especially on locomotives, should be of the best construction. We have arranged these accessories with a view both to convenience, durability, and greatest efficiency. Prominent among these "locomotive attachments" is the STARTING VALVE.

Starting valve

It is necessary in starting the instrument, particularly when it is required to lift water, that there should be a small supply of steam at first to bring the water up to the nozzle, and afterwards the full supply should at all times be given. Our starting valve, shown in Fig. 120, is operated by a lever, A; its stem, B, is attached to the valve D, with a lost motion between C and E. C is in fact a small valve in the centre of the larger valve, D. Pressure of the boiler

Use of centre valve.

is on top of valve on space G. Raising the lever and drawing up the valves, C will leave its seat on D,

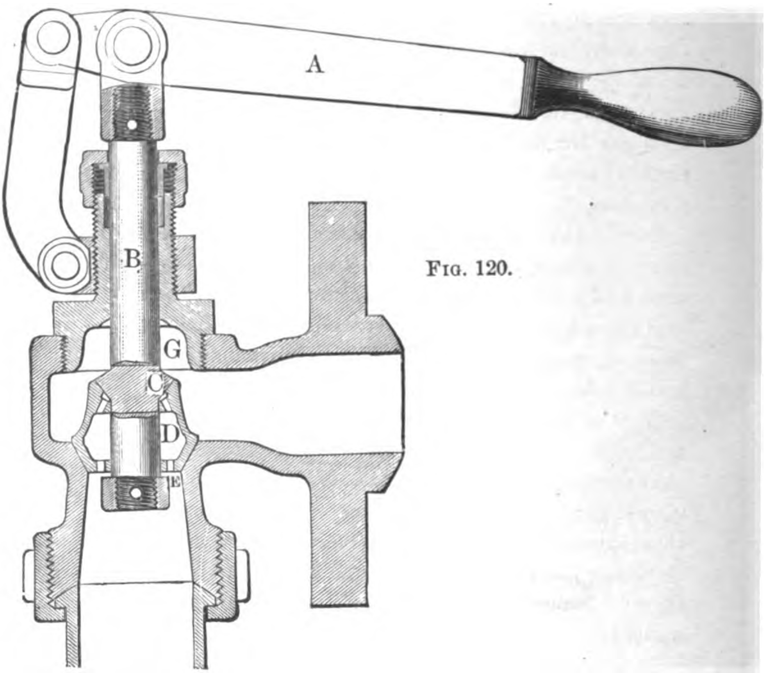
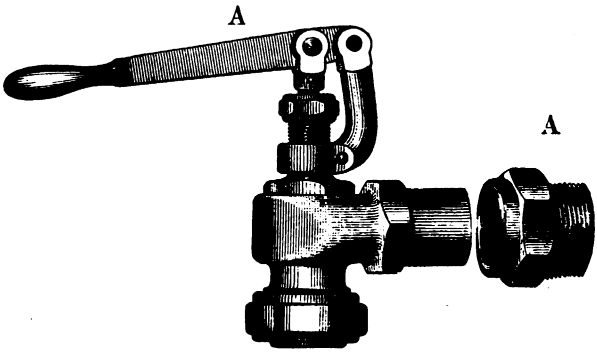


FIG. 120.

until a check nut at E has brought up against D. This resistance can be distinctly felt, and indicates when the small valve only is open. Through this small valve enough steam will pass to start the jet. A further motion of the lever then raises the large valve, and the pressure acting on the stem, B, forces it wide open and holds it in this position. These valves

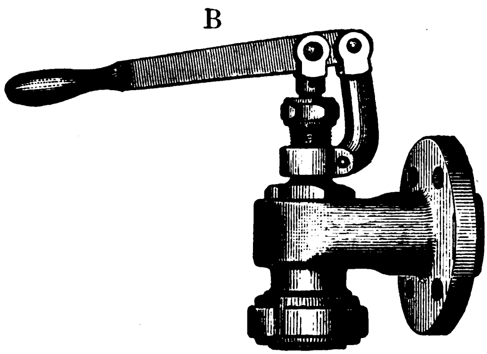
are, for convenience of attachment to boiler, made either with or without flanges, as shown in the annexed cuts.

FIG. 121.



(A.) STARTING VALVE, WITHOUT FLANGE.

FIG. 122.

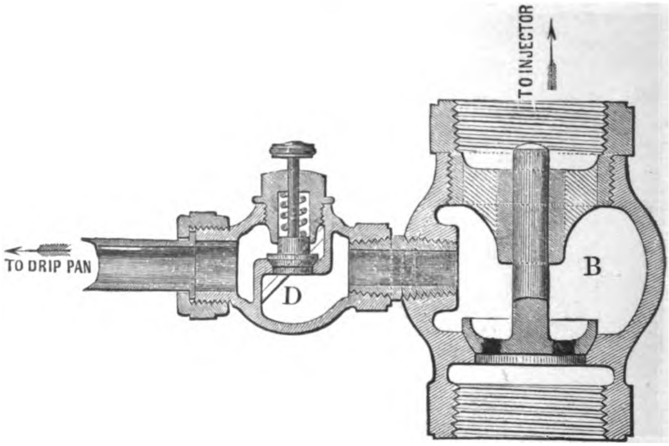


(B.) STARTING VALVE, WITH FLANGE.

As it is of vital importance that the engine driver should be notified whenever the injector, from any cause, either ceases to operate or fails to start, we provide an alarm check valve, shown in Fig. 123, as also in place in Plate II.

Alarm check.

FIG. 123.

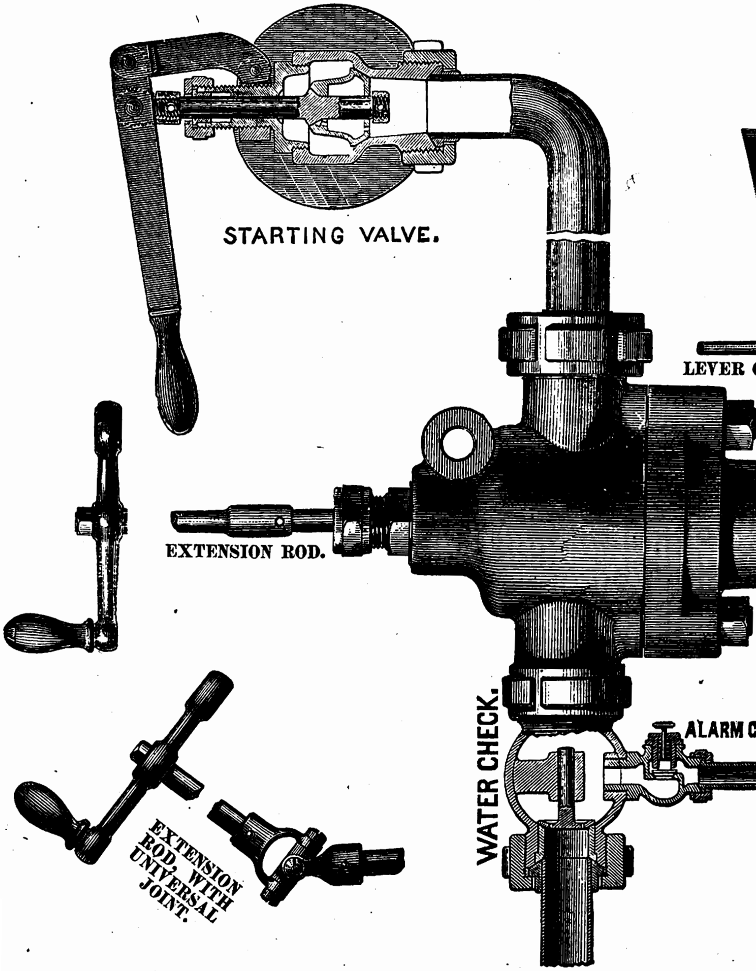


If steam flows back it is partially stopped by check *B*, and, acting under check valve *D*, raises it, and blows out through the waste pipe.

Water heater.

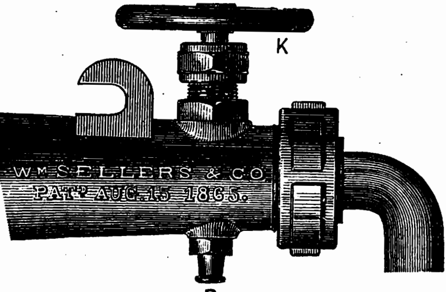
To enable the instrument to be used as a tank heater in cold weather, it is only necessary to close the waste valves of injector before turning on steam, when the jet cannot be established, but the steam will blow back through the instrument, and, passing through small holes in the valve *B* of water check, will enter the tank and warm the water. A stop valve must be placed in the pipe from the alarm check, to be closed when the steam is being forced into the tank; else it will escape through the alarm check.

LOCOMOTIVE

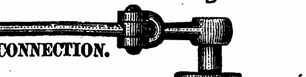

STARTING VALVE.
LEVER
EXTENSION ROD.
WATER CHECK.
ALARM
EXTENSION ROD, WITH UNIVERSAL JOINT.

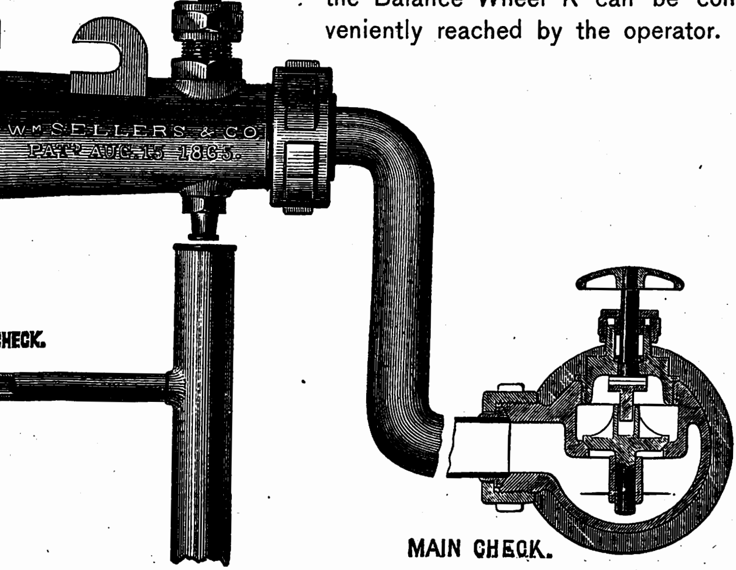
ATTACHMENTS.

PLATE II.



The Extension Rod and Lever Connection are not required when the Balance Wheel K can be conveniently reached by the operator.





MAIN CHECK.

It must, of course, be remembered that, after driving steam through in this way for some time, the feed pipe and its contents will become highly heated. It will, therefore, be impossible to start the injector until this very hot water has been drawn through and ejected by the escape valve.

The instrument will not start if too hot

If this precaution is neglected and the full head of steam is given to the injector before the hot water has all been expelled by the light jet, then, there being no condensation in the nozzle *C*, Fig. 116 (or an insufficient one), the jet will not be driven into the boiler, but will back up into the supply pipe, and will drive hot water and steam through the supply pipe to the tank, thus re-establishing the conditions securing failure; so that if another attempt is made at once to start the apparatus, it will fail, exactly as before, and so on perpetually, until the water in the supply pipe is no longer hot; an end to be reached in practice, of course, not by waiting until it cools, but by blowing it out, as before directed.

Cooling the injector.

To facilitate this cooling process, it is advisable to place a small drip cock on the lowest part of the supply pipe between the tank and the injector, as shown at *H*, Plate I.

Main check valve.

We come, lastly, in connection with these locomotive attachments, to the main check valve. The object of this, evidently, is to prevent the water of the boiler from running out through the injector, should anything go wrong.

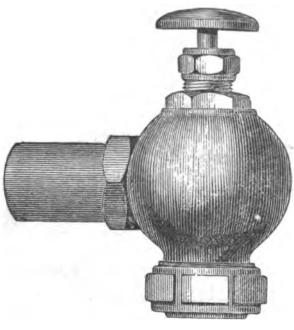
It is, moreover, so constructed that it not only acts as an automatic check valve, but it is also arranged so that if, by chance, it sticks up and fails to close, it may be forced down into its seat, and turned round so as to remove obstructions. (See Plate II., main check.)

To accomplish these objects, the upper part of the valve is provided with parallel plates cast with it, forming, in fact, a rectangular slot, in which fits freely a plate suspended from the T slide of the valve stem which ends above in a button. By this means the valve easily rises and falls, being guided by the part of the stem below the valve; but if it should stick up, it may be at once forced into its seat by pressing on the button, or turned round upon its seat so as to grind out any foreign substance without cramping its guiding stem.

These check valves are made for either right or left side of the locomotive, and with or without flanges, as shown in the annexed cuts (Figs. 124–125).

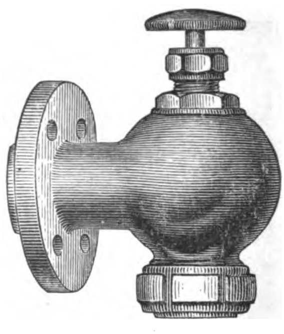
MAIN CHECKS.

Fig. 124.



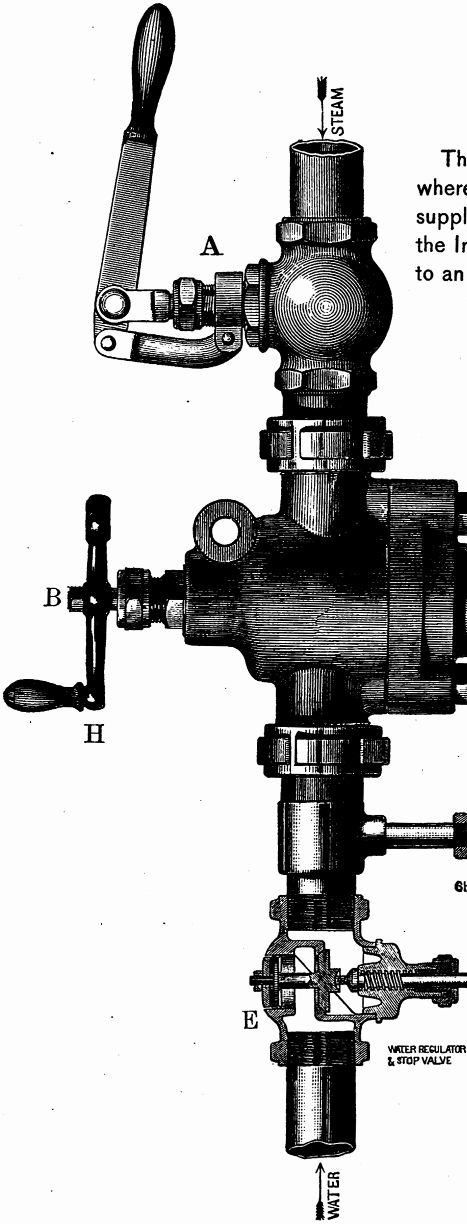
(C.) Ingress at bottom, for right or left side, without flange.

Fig. 125.



(D.) Ingress at bottom, for right or left side, with flange.

In connection with stationary engines, the only attachments required are the alarm check, main check, and, when there is pressure in the water supply, a water regulator in connection with the water check valve.

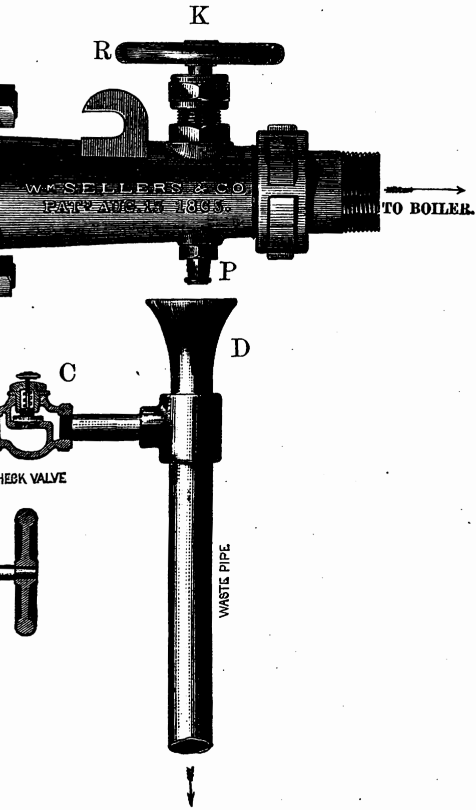


Th
where
suppl
the In
to an

STATIONARY A

PLATE III.

is cut represents the method of setting the Injector
e there is a considerable pressure in the water-
y pipe to Injector; where the water is lifted by
njector, the Regulating Valve B must be changed
ordinary Check Valve.



ATTACHMENTS.

Fig. 126

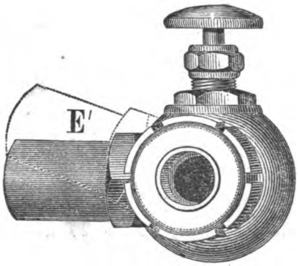
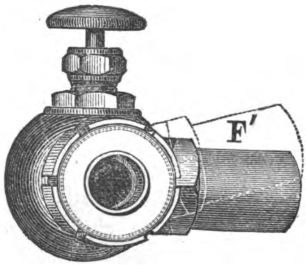


Fig. 127.



(E.) Ingress horizontal for right side, without flange.

(F.) Ingress horizontal for left side, without flange.

(E′ & F′.) Egress inclined upwards.

Fig. 128.

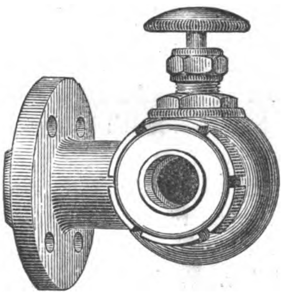
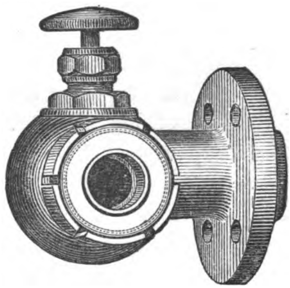


Fig. 129.



(G.) Ingress horizontal for right side, with flange.

(H.) Ingress horizontal for left side, with flange.

Water regulating valve.

This arrangement is shown in Plate III. Here we have a sort of balance valve, in which the water from the supply presses upon the inner face of the valve, and also upon the small piston on the same stem, whose outer surface opens to the air through the case. These surfaces are so adjusted that the valve would

remain closed by reason of the water pressure; but if a partial vacuum is produced in the pipe, *D*, by the action of the injector, then the valve will be opened by this force, the amount of its opening being controlled by the position of the stem which is detached from it.

Of course any pressure in the pipe, *D*, will at once close this valve, so that it acts also as a check valve, which would cause the steam to pass through the alarm check into the waste pipe, so as to attract notice.

In conclusion, we may add that the most convenient method of using waste heat to raise the temperature of the feed water with the injector, is to pass the water from the instrument through a closed heater where it can take up the waste heat, and not to attempt to heat the water before it enters the injector. By this means, using the exhaust from an engine as the source of heat, about 70° may be added to the heat of the water fed.

Use of a heater.

Injector utilizing exhaust steam.

A somewhat similar result may be obtained without a closed heater, by arranging an injector so that it may take in exhaust steam, thus raising the temperature of the water fed to boiler. We build instruments with this attachment, which can be advantageously used in situations where a pipe from the exhaust escape can be carried to the injector. Condensation in this pipe must be avoided, as the instrument will not draw in water from it.

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